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The Journal of HEREDITY

A monthly publication devoted to Plant Breeding Animal Breeding and Eugenics

SEPTEMBER, 1924

CANTONESE POULTRY
F. M. Fronda

CONSEQUENCES OF RACE CROSSING
W. E. Castle

SPORELINGS OF THE FERTILIS BOSTON FERN
Ralph C. Benedict

INHERITANCE OF COAT COLOR IN SWINE
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POLKADOT LEAVES IN MAIZE
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ALBINISM IN SORGHUM
Conner and Karper

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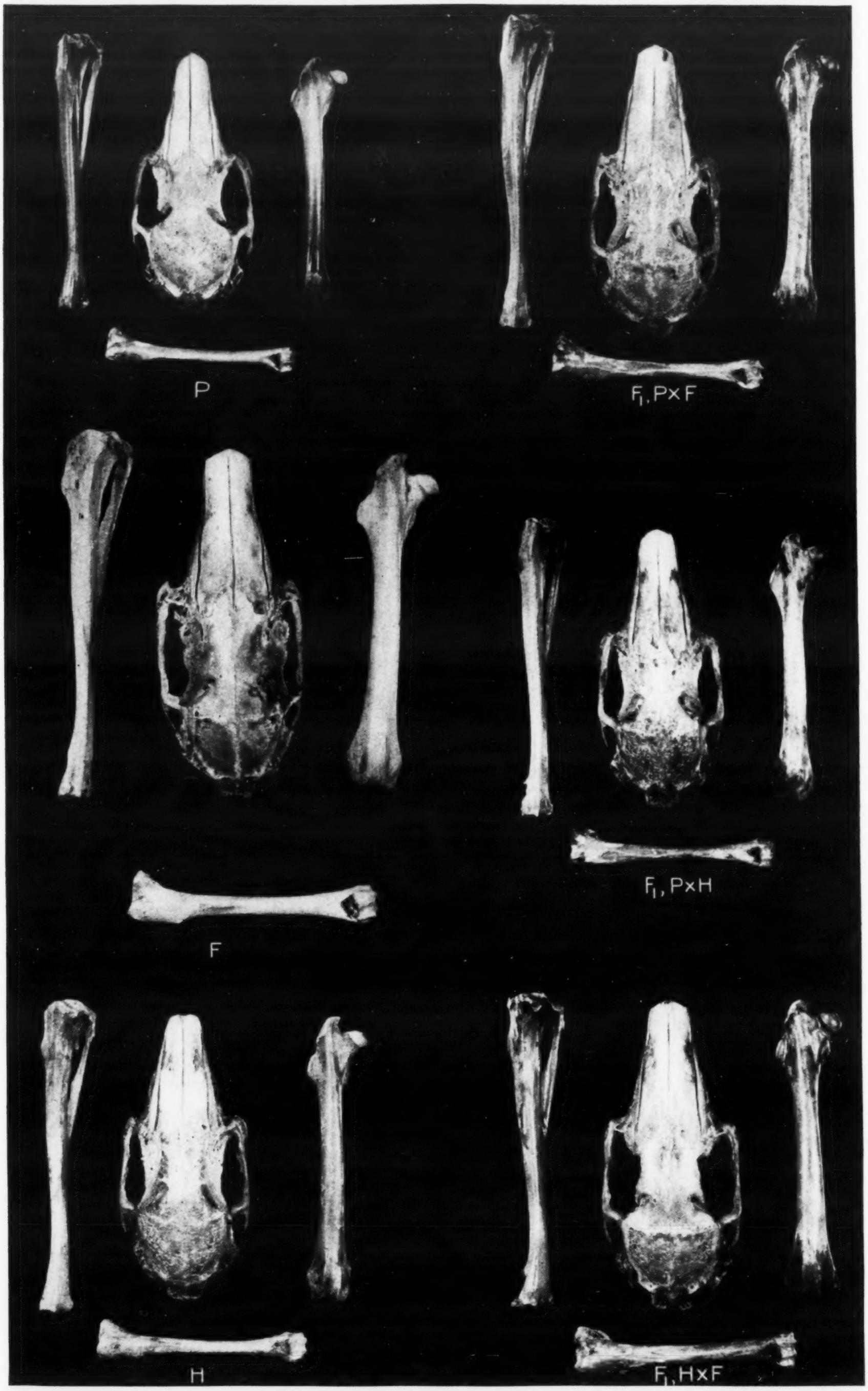

"SKELETAL MISFITS" NOT PRODUCED BY RACE CROSSING

Here are shown the skull and certain leg bones of a very large race of rabbits (F, Flemish Giant), of two small races (P, Polish, and H, Himalayan) and of first generation (F_1) hybrids between these races. The bones of each hybrid individual are intermediate in size between those of its parents, and among them occur no "disharmonies" or "misfits." Each set forms a harmonious and self-consistent system. This is equally true of the second generation hybrids. All the bones are shown in the same scale. (Frontispiece)

BIOLOGICAL AND SOCIAL CONSEQUENCES OF RACE-CROSSING

W. E. Castle
Bussey Institution, Harvard University

IN THE April, 1924, number of the Journal of Heredity, Professor S. H. Rice discusses the fertility of race hybrids as a possible factor of importance in moulding the future population of the United States. He bases the discussions on conclusions drawn by Dr. Mjoen, of Norway, from the results of experimental race crosses in rabbits. Since those experiments are capable of repetition, with consequent verification or disproof, it may be well to inquire into the soundness of Dr. Mjoen's conclusions before we apply them too confidently to problems of human population, which are incapable of direct experimental investigation.

Dr. Mjoen's general thesis is that racial crossing tends to produce physical deterioration both in rabbits and in humans. He admits the impracticability of investigating the question critically in human populations and for that reason has resorted to experiments with rabbits for critical evidence. He offers the results of two sets of experiments in one of which two different races of rabbits were crossed, in the other three. The evidences which he observes of physical deterioration are: 1. Increased size in F_1 (first hybrid generation), greater than that of either parent. This is regarded as a "weakness" because "abnormal." 2. Decreased size of some individuals in F_4 (fourth hybrid generation), which are smaller than either ancestor of pure race. Other individuals of F_4 are intermediate in size between the uncrossed ancestors. 3. Diminished fertility and increased mortality in the young in F_4 as compared with earlier generations. 4. Failure of the sexual instinct in many F_4 individuals. 5. Asymmetrical carriage of the ears, one erect, one pendant, among cross-breeds between lop-eared and albino rabbits.

The increased size of F_1 individuals is a phenomenon familiar to animal and plant breeders and frequently utilized by them. It is regularly attended by unusual vigor of growth and resistance to disease as well as by high fecundity. I have never before seen it mentioned as an evidence of physical deterioration. If it is "deterioration" to be "abnormal," all superior individuals have "deteriorated," because they are "abnormal." The races with which Dr. Mjoen started were "abnormal" as compared with the ancestral wild rabbit of Europe, all being medium to large sized (3400-4300 grams). The weights given for the F_1 individuals are 4160 and 4645 grams respectively. In F_4 weights are given for eight individuals, ranging from 2560 to 3850 grams. The smallest of these is well above the average weight of wild rabbits and so "abnormal." Is it an evidence of "deterioration" that some of these are less "abnormal" than their immediate ancestors, or that the group is more variable than the F_1 generation?

The diminished fertility of F_4 individuals and the increased mortality of their young more probably resulted from unsanitary environment than from the mixed racial nature of the parents. The animals are reported to have been kept in this generation one or two males in a common hutch with eight females. Rabbits cannot be bred successfully in such crowded quarters and it is not surprising that only one litter of young was obtained in a period of six months. Failure of the sexual in-

stinct and inability to produce viable young are well known consequences of an inadequate or unbalanced diet but not of race crossing in any species of animal that ever I heard of.

The asymmetrical carriage of the ears which Dr. Mjoen regards as "the most distinct outward sign of a disharmonic crossing that can well be imagined," and which he observes among three of his cross-bred rabbits, is a feature not confined to cross-breeds but of frequent occurrence among rabbits of large size, irrespective of race. Ear size in rabbits is closely correlated with body size, as I have shown elsewhere. When the ears are long, the muscles at their base are often unable to hold the ears erect, and they may lop over both to the same side, or one may lop over while the other remains upright. Ossification at the base of the ear adapts itself to this abnormal relation, as observed by Darwin (*Animals and Plants*) and the condition thus becomes permanent. The purest races of large rabbits, such as Flemish Giants and pure bred lop-eared rabbits, often show this asymmetrical ear carriage. Breeders naturally consider it a defect and in lop-eared rabbits seek to correct it in the young by mechanical means, such as manipulation with the hands to separate the connective tissue beneath the skin which joins the ears together. Books on rabbit-keeping figure leather caps to be placed over the top of the head of the young lop-eared rabbits to hold the ears apart and down. It is evident, therefore, that the asymmetrical ear carriage of Dr. Mjoen's rabbits was not due to their cross-bred state, since this same condition is found in uncrossed individuals of one, at least, of his "pure races."

From an experience of more than twenty years in the breeding of rabbits, in the course of which I have crossed nearly all known breeds, some of which differed much more in size and other characters than did those used by Dr. Mjoen, I am satisfied that there are no breeds of domestic rabbits so distinct racially that their hybrids show the slightest diminution in fertility or vigor, as compared with the uncrossed races. Breeds of rabbits show no more racial distinctness than breeds of cattle, which are so frequently crossed in the most enlightened agricultural practice, without any indications of diminished fertility being observed.

Dr. Mjoen's conclusions rest on insufficient and uncritical observations. It would not be necessary to point this out to an experienced geneticist, but the sociologist is perhaps entitled to a biological rating of these observations.

Organic Misfits

Dr. Mjoen's argument, if I understand him rightly, assumes that all inheritance in rabbits and in men is Mendelian, and that if this is so all possible recombinations of the inherited characters will occur in F_2 and later generations. Among these recombinations, he thinks, are sure to be many organic misfits, such as small legs on large bodies. It might be supposed that in the evolution of existing races organic misfits had been eliminated by natural selection, and therefore, that surviving types are superior types which could only be made worse by intercrossing, since the frequency of organic misfits must be increased by such crossing.

The question of the production of skeletal misfits in crossing the largest with the smallest known races of rabbits, I have subjected to an extensive and intensive experimental investigation, but I have failed to observe any indication of the occurrence of misfits either in F_1 or F_2. There is a remarkable constancy in the degree of correlation between part and part within the body, quite irrespective of size. The genetic agencies which control the size of particular parts are identical with the agencies which control the size of the body as a whole. From an intimate study of the subject I am able to deny categorically Dr. Mjoen's assumption that there is inheritance,

independent of general body size, of types of bone structure which regulate "the way or mode of jumping and holding—carrying—the body."

Why, it might be asked, if nature abhors race crossing, does she do so much of it? Why is it that distinct races of the same species of animal occur only where geographical isolation exists? Why does she go to such pains to ensure cross fertilization rather than self fertilization or close fertilization?

Are there such things as "harmonic" and "dishormonic" race crossings? It is assumed in Dr. Mjoen's argument that some combinations of inherited characters are better than others, have greater survival value, and for that reason are found in existing races. As race crossing brings about recombination of inherited characters, it is to be expected on genetic principles that mixed races will be more variable than unmixed races. Is such variability a disadvantage? Yes, if all *new* combinations are inferior to those which previously existed. This Dr. Mjoen seems to assume to be true in certain cases, as in Norwegian-Lapp crosses, which he regards as "disharmonic." From his viewpoint any infusion of Lapp characters into the Norwegian complex is deterioration. Perhaps the Lapp might reasonably take a similar view of the situation. Race pride and race prejudice narrow down to just that view of all alien stocks. But to an outside observer it is conceivable that *some* inherited characters of the Lapp might be combined with other inherited characters of the Norwegian to produce meritorious racial combinations, which would be viewed with satisfaction both by the intelligent Lapp and by the intelligent Norwegian. When these combinations had gained such recognition, Dr. Mjoen would doubtless designate them "harmonic race crossings."

Now is there any way, other than trial and error, by which harmonic can be distinguished from disharmonic race crossing? I doubt it. I doubt whether there is any race of human beings whose genetic qualities are all inherently bad. I doubt whether there is any human race so "superior" that it is incapable of improvement. Dr. Mjoen is looking for some simple "blood test" chemical or serological which will show whether a proposed mating, either inter-racial or intra-racial, is "harmonic" or "disharmonic." I doubt whether he finds it. The methods of genetic analysis of inherited qualities are far in advance of chemical knowledge of the material determiners of those inherited qualities. We may reasonably expect to learn more from a study of the genetic qualities of races and individuals and their mode of inheritance than from blood tests.

Race Crossing and Social Inheritance

I doubt whether there are any race combinations which are, so far as biological qualities are concerned, inherently either harmonic or disharmonic, that is productive of better or worse genetic combinations. Both better and worse should theoretically result, if all inherited characters follow Mendel's law in transmission. A more variable population would then result, which should be on the whole more adaptable to a new or changing environment either physical or social. Is it not possible that the racially mixed character of the populations of France, Germany, England and the United States have been one factor in their adaptability to social and economic changes?

If all inheritance of human traits were simple Mendelian inheritance, and natural selection were unlimited in its action among human populations, then unrestricted racial intercrossing might be recommended. But in the light of our present knowledge, few would recommend it. For, in the first place, much that is best in human existence is a matter of social inheritance, not of biological inheritance. Race crossing disturbs social inheritance. That is one of its worst features. And, limiting our attention to biological characters only,

few of them follow the simple Mendelian law, with presence or absence of single characters, dominance or elimination. Most inherited characters are blending. When parents differ in a trait, the offspring commonly possess an intermediate degree of it. This is true of stature, weight, and, I think, of general mental powers. Neither parent is devoid of stature or weight or is without mental ability. The children as a rule are intermediate between their parents as regards such traits. It is so in racial crosses, except for the complication of hybrid vigor or "heterosis" in the F_1 generation, a well known occurrence both in animal and human crosses. When two races cross which differ in stature, the children may surpass either parent in this respect, as Dr. Mjoen has observed. But the "overgrowth," as he well calls it, does not persist into later generations. It disappears, as heterosis disappears, and the population of later generations will be intermediate in character, though probably more variable than either uncrossed race. This is the outcome in numerous careful experimental investigations among animals, and may confidently be predicted as the result with similar characters in the crossing of human races.

When traits blend in human crosses, deterioration is not to be expected as a consequence, but rather an intermediate degree of the characters involved. Whether from a purely biological standpoint a particular race cross is considered desirable or undesirable will depend on whether a greater or less degree of the characters under consideration is desired.

Race Crossing in the United States

Consider for a moment the physical (not social) consequences in the United States of a cross between African black races and European whites, an experiment which has been made on a considerable scale. The white race has less skin pigment and more intelligence. The first difference will not be disputed, the second can be claimed at least on the basis of past racial accomplishment. As regards skin color the F_1 hybrids are intermediate; as regards intelligence it is not so easy to judge, since their environment has commonly been that of the blacks, but it will be generally admitted that they are superior in this respect to the blacks and that this has been a factor in their social advancement which has been more rapid than that of the blacks. Repeated back-crosses with whites, if permitted, might be expected to result in an approximation to the skin color and level of intelligence of the whites in a few generations. Similarly back-crosses with the blacks would naturally result in an approximation to their physical and mental standards. Matings of F_1 individuals *inter se* would continue indefinitely a race varying about intermediate standards, but varying more widely than either uncrossed race.

So far as biological considerations are concerned, there is no race problem in the United States. If social considerations were not much more powerful than biological ones, the future population of the United States would certainly be highly variable in skin color and intelligence, passing by scarcely perceptible gradations from a pure black type of the present "black belt" to a pure white type such as would result from a mixing of European races. But the social considerations *are* of much more importance than biological ones in this connection, and the racial future of the United States cannot be predicted from the latter alone.

Mixed Races from Inferior Stocks

Dr. Mjoen would like to believe that the mixed race constituent of Norway's population will die out of itself, because he finds that it coexists with bad physical and social states of the population. He seeks biological support of this hope in animal experiments, but will not find it, I think, if those experiments are made critical and interpreted

without bias. He should investigate also the social environment under which race crossing occurs and in which the hybrids are forced to live. In these, if I mistake not, rather than in any mysterious biological disharmonies, will be found the explanation of the alleged greater prevalence of tuberculosis, drunkenness, theft and other social evils among the mixed population. He should inquire what sort of individuals contract mixed marriages, and under what conditions. Are they the best or the worst of their respective races? Do those who contract such marriages do so from deliberate choice or only because they can find no eligible mates among their own people? Are they individuals of force of character with passions well under control, or are they of the feebler sort, yielding readily to impulse and with unbridled passions? Is it to be expected that a cross between poor specimens of two races will result in anything but poor offspring? It is illogical to ascribe the poor quality of a mixed race to the fact that it is a mixture, provided that the original ingredients are poor. How could it well be otherwise?

Consider also the social environment in which race crossing usually occurs and in which the hybrids grow up. Crossing occurs clandestinely or, if in legalized wedlock, between individuals lost to shame. For parties to such matings are despised by both races and their children are social outcasts. Their social opportunities are decidedly limited. Is it any wonder that their social attainments are limited and that they show lack of the ordinary social inhibitions? It is not necessary to invoke biological disharmonies in order to explain the poor results of many race mixtures. Social agencies afford a sufficient explanation.

Outlook for the Mulattoes

Let us consider further, in this connection, the black-white race mixture in the United States. According to Willcox, about nine-tenths of the present population of the United States consists of whites without admixture of African blood, the other tenth consisting of blacks or black-white hybrids, known as mulattoes. If there were free intercrossing of all elements of the population, the proportion of mixed bloods should steadily increase, but this has not been the case in the past and is not likely to be in the future. At the first United States Census in 1790, according to Willcox, the negroes and mulattoes constituted about one-fifth of the total population, or twice the proportion they now represent. Instead of the increase which random matings would produce, there has been a steady decrease in the proportion of blacks and mulattoes. This has been due in part to white immigration, in part to a lower rate of increase among the blacks, but chiefly to a strong social prejudice among the whites against mixed marriages, which in many States has found expression in legislation against miscegenation, and in all States takes the effective form of a strong public sentiment against it. This same public sentiment insists on classifying as black every individual who is known to have or is suspected of having any trace of negro blood in his veins. The consequence is that marriages between whites and blacks or mulattoes are at present extremely rare and clandestine unions are uncommon.

So far as back-crossing of mulattoes with blacks is concerned, this probably does not occur with random frequency, since pure-blooded negroes on one hand and mulattoes on the other, have each a degree of group consciousness which tends to keep them apart. The mulattoes as a rule are more intelligent and have enjoyed better educational advantages so that they find more ready employment in urban life as porters, janitors, or even in clerical or professional occupations. But with urban life goes a reduced birth rate among blacks as well as whites. The prospect is that,

if things go on as they now are, the mulattoes will not amalgamate either with the whites or with the blacks, but will form a separate but diminishing proportion of the total population. The blacks are holding their own in certain rural sections of the South, but elsewhere are going back numerically. No complete amalgamation of blacks with whites is to be anticipated, simply because of social impediments, though no biological barrier whatever is discoverable.

Indian-White Crosses

Another distant racial cross which has been made on a considerable scale in North America is that between European whites and North American Indians. To be sure, the number of hybrids resulting from this cross is insignificant compared with that of the mulattoes, but it is sufficient to be instructive as a biological and social experiment. The early English colonists kept close to the coast and steadfastly refused to associate with the "savages," but the French in Canada were more disposed to roam the woods. Their young men explored the interior of the continent, lived with the Indians as trappers and hunters and often took Indian wives. Thus a half-breed population grew up of hardy adventurous frontiersmen. It would be difficult to find in them evidences of physical or intellectual degeneracy, other than those entailed by the introduced vices of the white race.

Within the United States, the settlement of the Mississippi Valley took place so rapidly that it amounted to a complete dispossession of the Indian tribes found there. These moved bodily westward to "reservations" beyond the great river. Accordingly there was little opportunity for race mixture. Nevertheless, renegade whites, who had reason to lose their identity temporarily, often joined the Indians on their reservations. As the reservation lands became valuable through the occupation of the surrounding territory by whites, the "squaw men" and their half-breed children found it an economic advantage to be members of the tribe. So when later the wild Indians were domesticated and "given lands in severalty," the individuals of mixed race often found themselves wealthy land owners. This gave them social advantages which resulted in frequent marriage alliances with the whites. For there is no strong social prejudice against the red man such as exists against the black man, recently a slave. Consequently the pure-blooded Indians are a rapidly vanishing element of the population of the United States, and those of mixed race are being rapidly assimilated in the white population, frequently attaining positions of influence and authority. The difference in results following crossing with the black and with the red races in the United States are not referable to any biological harmonies or disharmonies existing in the respective cases but wholly to the social attitude of the whites, which is hostile in one case, indifferent in the other.

A further illustration of the surpassing importance of social over biological considerations in race-crossing is seen in the attitude of the Pacific Coast States towards Chinese and Japanese intermixture. No one questions the virility of these races or their biological fitness. Their cultural attainments are very high and antedate our own. Hybrids between these races and white races, so far as our information goes, are of high quality physically and intellectually. Yet public opinion is unalterably opposed to Oriental immigration or race mixture, not on biological grounds, but purely on social, economic, or political grounds.

So far as a biologist can see, human race problems are not biological problems any more than rabbit crosses are social problems. The rabbit breeder does not cross his selected races of rabbits unless he desires to improve upon what he has. The sociologist

who is satisfied with human society as now constituted may reasonably decry race crossing. But let him do so on social grounds only. He will wait in vain, if he waits to see mixed races vanish from any biological unfitness.

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The Superstition of "Character Analysis"

Everyone attempts, on occasion, to judge of character by external traits, and such attempts have been systematized in a psuedo-science by a modern school of Character Analysis, which is the heir to the mantle of the earlier Phrenology. The methods of character analysts have enjoyed a certain vogue among business men, and have been used in various industrial plants. These methods have now been put to the test by Glen U. Cleeton and F. B. Knight, who publish their results in the *Journal of Applied Psychology* (June, 1924).

The traits studied were sound judgment, intellectual capacity, frankness, will power, ability to make friends, leadership, originality, and impulsiveness, these being selected partly because the writings of character analysts agree on the physical evidences of these more than they do on most other points.

Three groups of students, ten in each, were rated by their closest associates; their physical traits were then carefully measured. To take a single example, "judgment" called for the measurement of twenty-eight different facial or cranial features, which character analysts have named as certain indices of the trait.

It was found in this and all other tests that there was no constant relation whatever between the mental traits and the physical ones named as going with them. In other words, the claims of character analysts were found to have no scientific basis whatever.

P. P.

INHERITANCE OF HARELIP

BERT CUNNINGHAM

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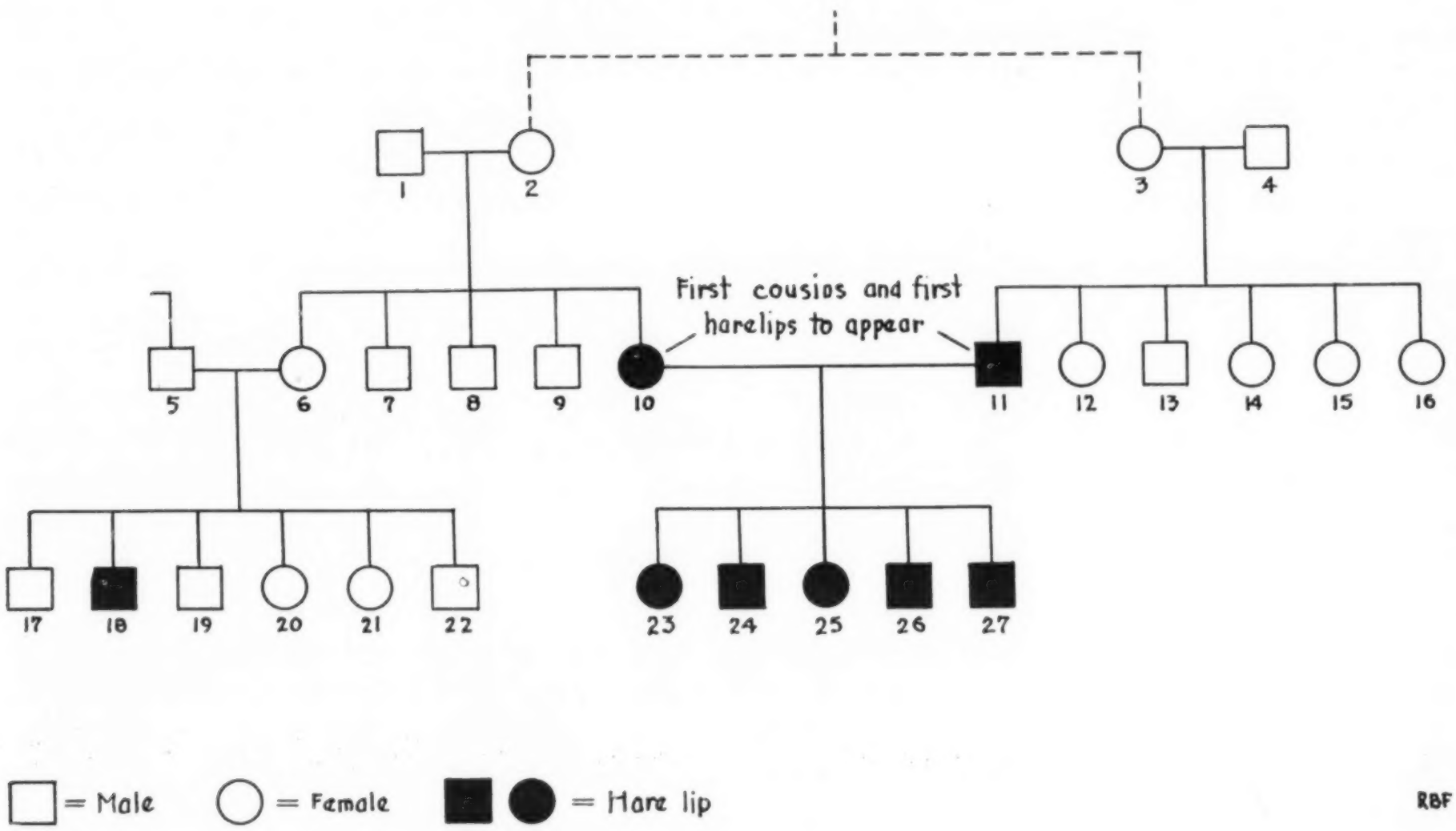

HOW IS HARELIP INHERITED?

(Figure 1)

THE accompanying chart was prepared from data furnished by a student in one of my courses in heredity, and may add to the information concerning the inheritance of harelip. Information further back than indicated by the dotted line was not available. Number two and number three were sisters. The interpretation of the data is left to the geneticists.

NOTE:—This chart hardly gives sufficient information to enable the most hardened geneticist to make a diagnosis, but it might serve as the basis of a fairly good guess. At least it tells us something about the way harelip is *not* inherited, which is certainly valuable. Many defects are carried in the germ plasm in Mendelian fashion and if this is true here, we may have a simple recessive character, certainly not a dominant one, nor one sex-linked or sex-limited.

Earlier writers, who have occasionally remarked that harelip runs in families, do not go much beyond this statement, and few if any pedigrees have been published. Only by putting such bits of information on record can we hope to gain accurate knowledge of many obscure questions of human heredity.—Editor.

CANTONESE--A NEW BREED OF POULTRY*

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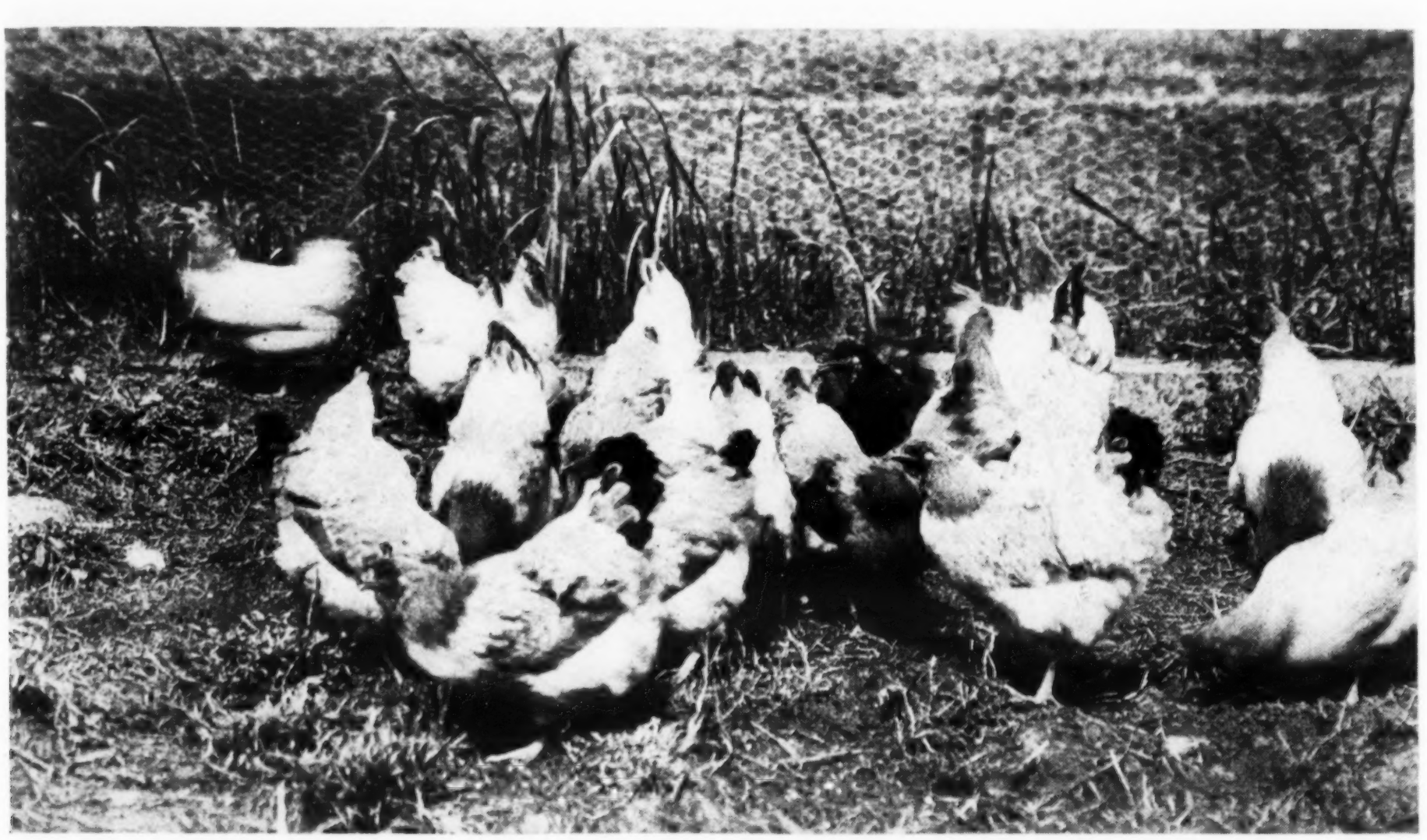


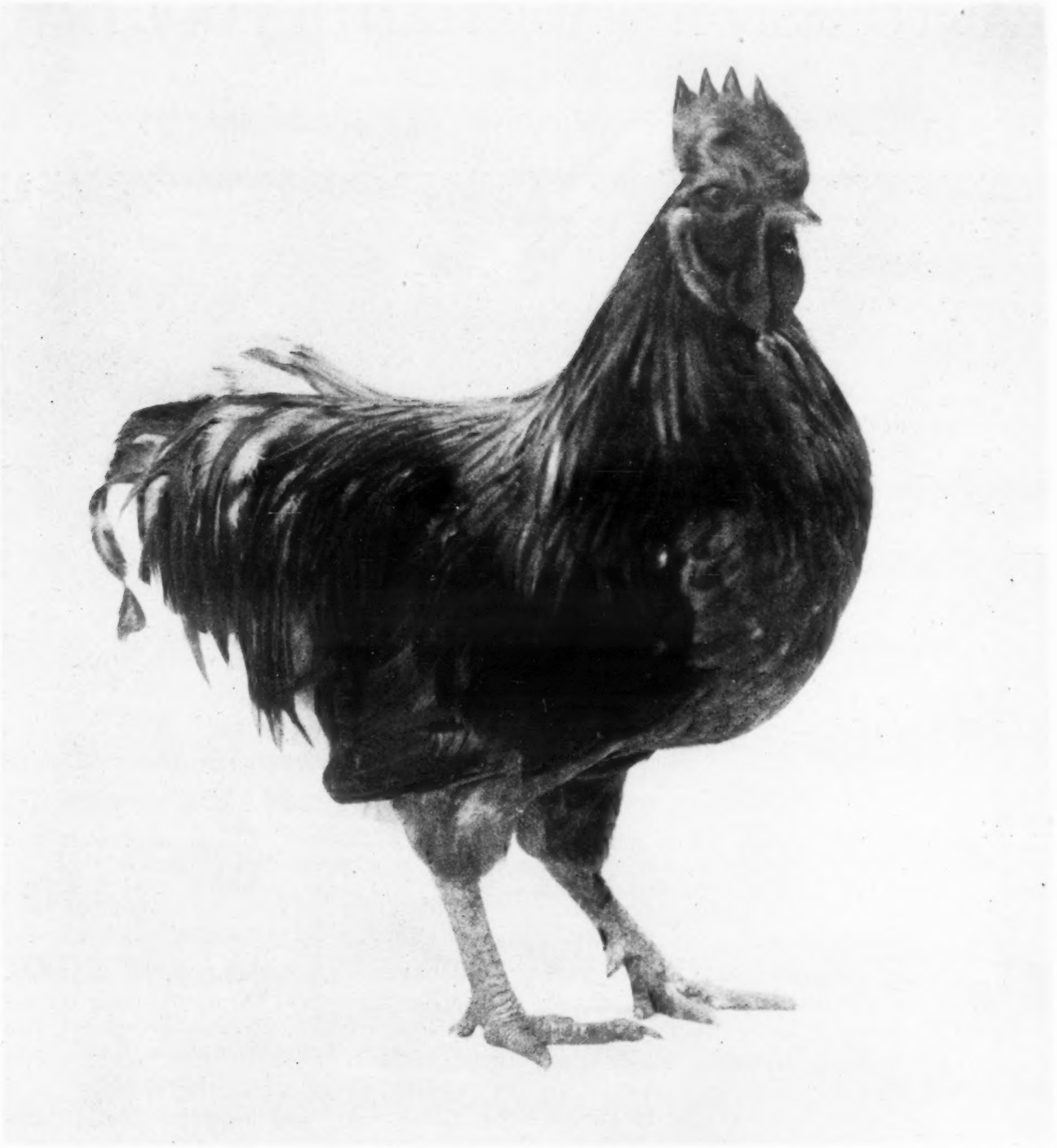
A FLOCK OF CANTONESE PULLETS

FIGURE 2. This is the native breed in the region of Canton, China, whence it was imported into the Philippines in 1914, where the Cantonese thrive better than any of the standard breeds of poultry. By selection a more uniform and productive type has been developed.

IN MOST of our breeds of animals the records of their exact origin is not very well known. Wild animals were brought under domestication and taken to regions having different conditions, often new to them. Peculiar environments in isolated places acted on groups of animals for generations and produced common definite markings and characters, thereby evolving what are now known as "local breeds." The Jerseys and the Guernseys furnish the best examples of breeds of live stock produced under such exceptional conditions. Among poultry, the majority of the present breeds of fowls have originated in a similar way, although a number of the more recent ones have been produced by a more deliberate process.[1,2] The Asiatic continent is credited with the origin of the three most popular of the meat breeds of poultry, the Cochin, the Brahma, and the Langshan, and now comes a possible new breed, this time a general purpose fowl, the origin of which can be traced back to Asia. This is the "Cantonese," the most common chicken in South China. It is not at all improbable that the greater bulk of the eggs exported annually from that part of China are produced by this group of chickens.

In China, this fowl is known in Cantonese as "Wong Kai," or Yellow Fowl.[3] It is very common in the

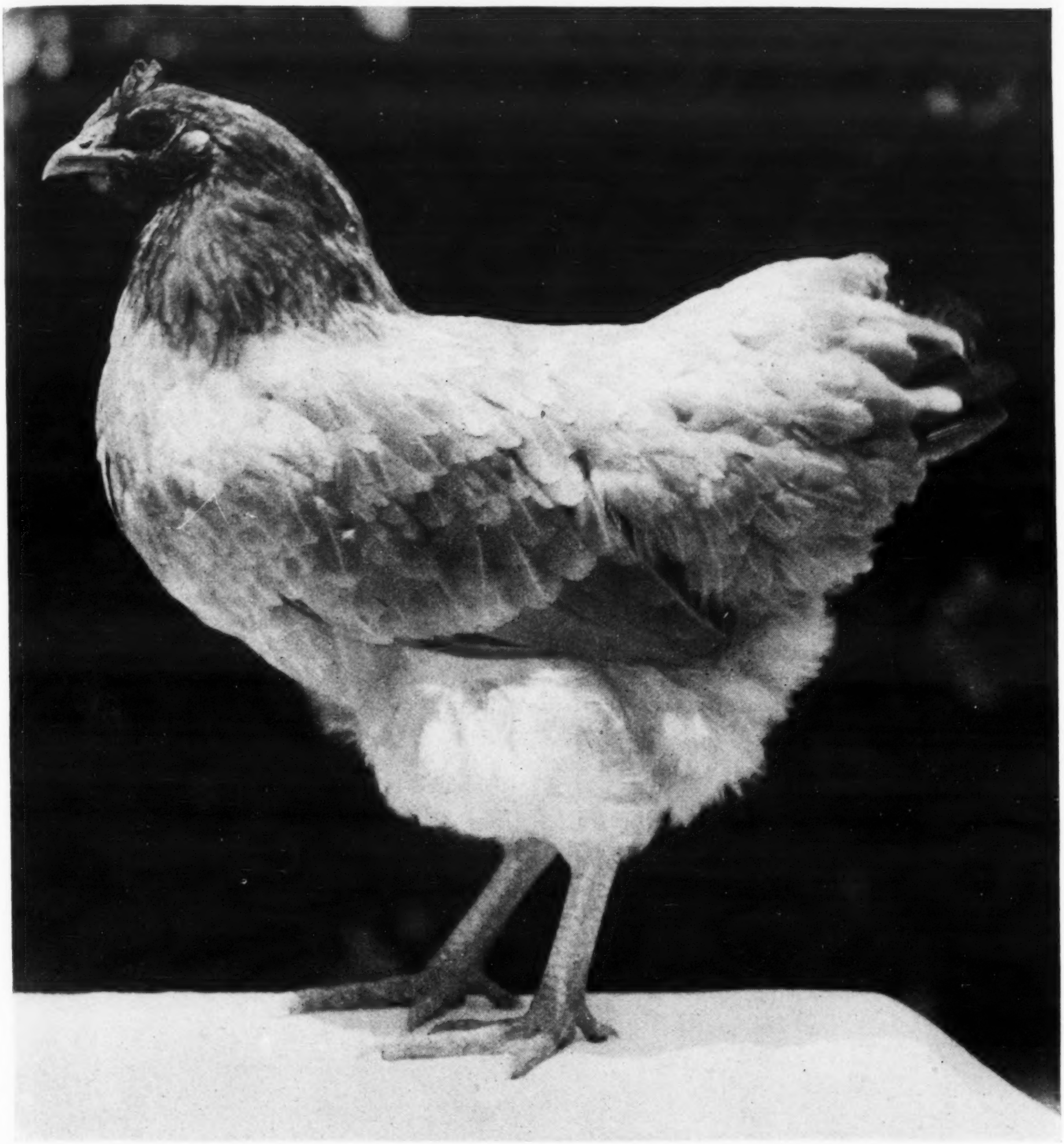
*Contribution from the Department of Animal Industry, College of Agriculture, University of the Philippines, at Los Banos, Laguna, P. I.



A CANTONESE COCKEREL

FIGURE 3. The cockerel of this breed tends to be a darker buff than the pullet, frequently being only a shade lighter than a Rhode Island Red. The shape is typical of the Cantonese, and further selection is being centered in the improvement of the color, size, and some of the minor standard qualities.

regions around Canton. When the first importation of these chickens arrived in the Philippines they were called "Cantonese" and by this name they are still known. These fowls have become very popular in this country, as they respond very favorably to local environmental conditions, and the native methods of feeding, care and management. This warrants the carrying on of work towards the improvement of their color, size, and egg production. The results obtained from the work thus far carried on in the College of Agriculture of the University of the Philippines strongly indicate that the Cantonese can be made a factor of some importance in the development of the poultry industry



A CANTONESE PULLET

FIGURE 4. Such a body type is characteristic of the Cantonese. Much more is expected in the improvement of the color, and in the quality of the eggs, which should be light brown, and not weigh less than twenty ounces to the dozen.

in this part of the world. For this reason it is necessary that a definite standard for the breed be formulated to serve as a guide for further work in its improvement.

In the part of China where this fowl originated there is a great demand for chickens that will grow into excellent roasters, and at the same time produce a fairly satisfactory number of eggs. This dual purpose must be accomplished without demanding much of the time of the people, as no special attention is paid to poultry raising in that region. It is probable, then, that the Cantonese is principally the product of the environmental conditions present in the region of the city of Canton. Possibly in addition to being a product of unconscious selection to produce a fowl

best suited to its environment, the Cantonese chicken contains a mixture of the black Frizzles, and also the white Silkies, as these two breeds were received with the original Cantonese chickens in the first shipment which arrived in 1914.[3] What influence these two breeds may have had in the development of the Cantonese is not known. It may be noted that the number of off-colored birds in our stock of this breed at Los Banos has been reduced to an almost negligible quantity through careful breeding and selection. While young, the Cantonese certainly makes a very satisfactory roaster, and the hens produce a goodly number of fairly large eggs. The birds are active and are very hardy, remaining healthy under conditions under which all the other imported breeds do not thrive.

The color of these birds is rich golden buff, with a tendency to black striping extending down the middle of each hackle feather at the lower part of the neck among females, and among the males toward a darker buff, frequently approaching a shade lighter than that of the Rhode Island Red. One or more mealy primary feathers may be present in the males, and in both sexes, the main tail feathers are black. The feathers all over are richly glossed. The comb, face, wattles, and ear lobes are bright red; the skin, the shanks, and the toes are yellow. A reddish horn is present on the upper mandible, and all the rest of the beak is yellow. The birds lay oval and mostly light brown eggs. A judicious selection is now being carried on in the College of Agriculture to improve further the color of the plumage of the birds and to secure greater uniformity in the color of the eggs produced.

The shape of the body is a "typical dual purpose" type, and corresponds somewhat to that of the Wyandotte. The body is well carried and is set on moderately short but stout legs. The bird is loosely feathered. It is active but not excitable in temperament, and the hens make fairly good mothers when used in natural incubation. The roosters are peaceful; they very seldom fight with each other.

The standard that is being followed in this College in all the selection work for further improvement of the breed is:

Standard Weights

Cock	3.0 kilos	(6.6 lbs.)
Cockerel	2.5 kilos	(5.5 lbs.)
Hen	2.0 kilos	(4.4 lbs.)
Pullet	1.5 kilos	(3.3 lbs.)

Shape of Male

Comb: Single, medium size; set firmly on the head; straight, upright; evenly serrated; with well defined points; fine in texture.

Beak: Stout, comparatively short; regularly curved; reddish horn.

Head: Short, medium size; face, smooth.

Eyes: Full, prominent; bright; reddish brown.

Wattles: Medium size; nicely rounded at the lower edges; equal in length; smooth texture; free from folds or wrinkles.

Ear-Lobes: Red; oval; smooth.

Neck: Short; well arched; hackle abundant; flowing well over shoulders; with no apparent break of cape.

Wings: Medium in size, closely tucked to body; sides well rounded; primaries and secondaries, broad, and overlapping in natural order when wing is folded.

Back: Moderately short, broad in its entire length, flat at shoulders; saddle feathers abundant.

Tail: Short, well spread at base, carried at an angle of 45 degrees above the horizontal. Sickles moderately long curving gracefully and closely over the tail; coverts, abundant; main tail feathers, black, broad and overlapping.

Breast: Broad, deep, round.

Body: Moderately short, deep, round.

Fluff: Short, full, well rounded.

Legs and Toes: Thighs, short, stout, well covered with soft feathers; shanks, yellow, moderately short, stout, set well apart, not feathered; toes, four in number, straight and strong.

Shape of Female

Comb: Single, small, proportional to size of specimen; set firmly on the head; straight, upright, evenly serrated, with well defined points; fine in texture.

Beak: Stout, comparatively short, regularly curved, with reddish horn.

Head: Short, medium size; face smooth.

Eyes: Full, prominent; bright; reddish brown.

Wattles: Medium size, nicely rounded at the lower edges, equal in length, smooth texture, free from folds or wrinkles.

Ear-Lobes: Red, oval, smooth.

Neck: Short, well arched, hackle feathers abundant, flowing well over the shoulders

A CORNER OF THE POULTRY PLANT OF THE UNIVERSITY OF THE PHILIPPINES

FIGURE 5. Where the climate is perpetual spring and the grass always green is the home of the new Cantonese breed. Curiously enough none of the standard breeds thrive under these apparently ideal conditions, and the Cantonese is being developed to meet a very definite need. The building housing the poultry office and class rooms is covered by the tall tree in the center of the picture. Mt. Makiling, the National Botanic Garden of the Philippines, can be seen in the background.

A COMMON TYPE OF POULTRY HOUSE IN THE PHILIPPINES

FIGURE 6. It is made of bamboo poles, thatch, and chicken wire. The very uniform climate of the Philippines makes it unnecessary to have strong, weatherproof poultry houses, such as are used in the United States. The Cantonese respond very favorably to the local environmental conditions, and to the native methods of feeding, care, and management.

with no apparent break of cape; rich buff with black stripe extending down to a point near its lower extremity.

Wings: Medium in size, closely tucked to the body; sides well rounded; primaries and secondaries, broad and overlapp.ng in natural order when wing is closed.

Back: Moderately short, broad, in its entire length, flat at shoulders, rising in a concave sweep at a broad, slightly rounded cushion, which extends well on to main tail; plumage, abundant.

Tail: Short, well spread at base, carried at an angle of 30 degrees above the horizontal; coverts abundant; main tail feathers, black, broad and overlapping.

Breast: Broad, deep, round.

Body: Moderately short, deep, round.

Fluff: Short, full, well rounded.

Legs and Toes: Thighs, short, stout, well covered with soft feathers; shanks, yellow, moderately short, stout, set well apart, not feathered; toes, four in number, straight, and strong.

The following characters are considered as disqualifications, and birds showing any one or more are culled and prevented from further breeding:

Shanks other than yellow.

One or more feathers, or any unmistakable indication of feathers on shanks and toes.

White in ear-lobes.

Birds laying eggs other than light brown in color, and those laying eggs weighing less than 20 ounces per dozen.

Birds that are off-colored.

Birds possessing any other deformity inherent in other standard breeds.

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[3]Levine, Carl Oscar. Notes on Farm Animals and Animal Industries in China. *Canton Christian College Bulletin No.* 23:6-13. 1919.

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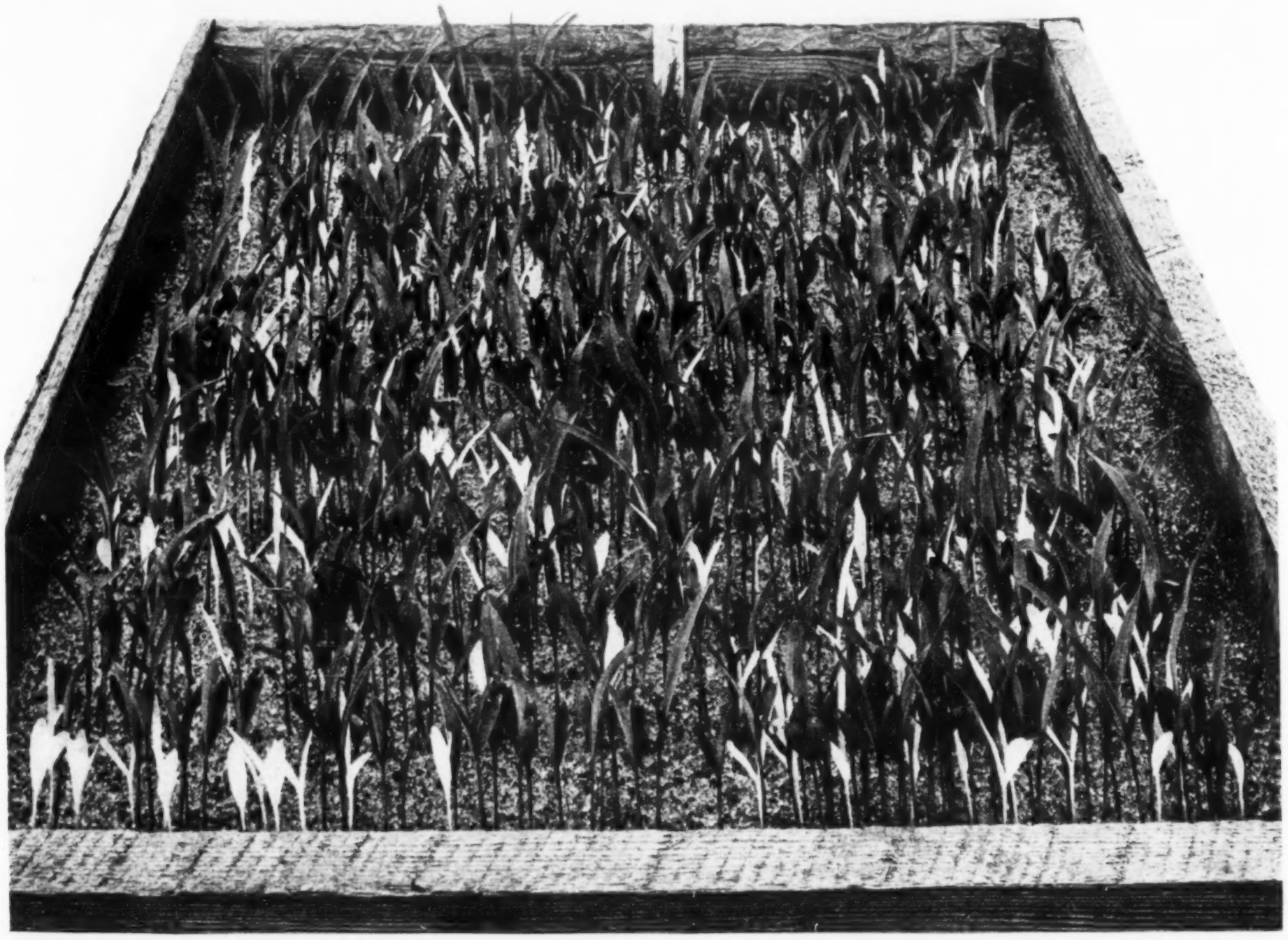
CHLOROPHYLL DEFICIENCIES IN SORGHUM

A. B. Conner and R. E. Karper
Texas Agricultural Experiment Station



ALBINISM IN KAFIR

Figure 7. Such undesirable forms, which are constantly occurring under natural conditions, may be eliminated by the plant breeder, thus improving the quality of the seed and increasing its value. Many similar defects are known to occur in maize and in other crop plants, and in nearly all cases albinism is inherited as a recessive character, but in kafir the mode of inheritance has not been definitely determined.

IN THE spring of 1923, Dr. G. N. Stroman, of this station, observed in a plat of Sudan grass soon after germination some albino, and virescent white seedling plants. Subsequently, in the same season, the writers found albino seedling plants in a plat of Standard Blackhul kafir and noted other seedlings that appeared to be virescent whites. The following winter the seeds from a number of kafir heads were germinated separately in seed-boxes in the greenhouse, with the result that one head from family 192 proved to be segregating for greens, virescent whites, and albinos. The ratios obtained were unsatisfactory, and further work is necessary to determine the number of factors involved. A head from another family, 223, proved to be segregating for greens and albinos only. The ac-

companying photograph shows a seed-box planted to a single head of this latter family, 223, and segregating for greens and albinos. The number of greens and albinos obtained in this case was 834 and 222, respectively. This ratio, 3.75 to 1, does not justify conclusions as to the number of factors involved; however, work is now in progress toward this end.

Electricity and Life

INJURY, RECOVERY AND DEATH IN RELATION TO CONDUCTIVITY AND PERMEABILITY, *by* W. J. V. OSTERHOUT, Professor of Botany, Harvard University. J. B. Lippincott Co., Philadelphia, 1922. 259 pages with figures. Price $2.50.

This volume is one of the series of monographs on subjects in the field of experimental biology begun under the editorship of Jacques Loeb, T. H. Morgan and Professor Osterhout himself, with the purpose of making the results in specialized fields easily available to biologists in general.

The present monograph is devoted largely to a description of the author's experiments bearing on the quantitative treatment of vitality, injury, recovery and death of tissues. The method is primarily the measurement of the electrical resistance of tissues under different situations. Pieces from the fronds of the kelp, *Laminaria agardhii,* were used most extensively. These pieces were found to maintain a nearly uniform resistence for days in sea water before a gradual decline set in, ending in death at a resistance only ten per cent of that at the beginning.

The behavior of the resistance in toxic solutions of various sorts and in various antagonistic mixtures, the course of recovery on return to sea water and degree of permanent injury, are among the problems investigated. The author's principal thesis is that these fundamental phenomena depend merely on the relative rates of the processes in a certain chain of irreversible monomolecular reactions. Fall in resistance with injury, for example, is looked upon as due merely to change in the relative rates in the same chain of processes which go on under normal conditions, and recovery from injury is looked upon, not as a reversal of the processes involved in injury, but as a readjustment of the rates among these same reactions.

The reader cannot but be impressed by the accuracy with which the hypotheses explain the behavior of the pieces of kelp and other tissues tested, not only in simple experiments but in experiments in which the pieces are transferred at varying intervals through a succession of different solutions. The hypotheses certainly fit.

It is not so clear that they are the only hypotheses that would fit. There is so much flexibility in fitting chains of monomolecular reactions to data that the reader is left with a somewhat uneasy feeling as to the reality of the processes described. Moreover, it takes four distinct mechanisms to explain temporary injury, rate of recovery, permanent injury, and antagonism, respectively.

While some doubts may be entertained as to the finality of the particular hypotheses advanced, there can be only admiration for the quantitative method of approach to these fundamental problems. The book should be a stimulating one for all of those interested in any phase of experimental biology.

S. W.

VARIATION AMONG THE SPORELINGS OF A FERTILE SPORT OF THE BOSTON FERN*

RALPH C. BENEDICT
Brooklyn Botanic Garden

THE PRESENT paper deals with a series of new forms which have arisen in the spore cultures of the only known fertile variety in the whole Boston fern series. Several papers have been published dealing with the bud sports of the Boston fern and its descendant varieties[1]. These bud sports have been mainly named varieties from the florists' trade which have originated from time to time during the last twenty-five years, and in as many separate establishments. Each new form has appeared as a single divergent plant among thousands of uniform progeny manifesting the characteristics of the parent form. Their study and description has involved the tracing and gathering together from their various points of origin of every form as far as possible, to which a distinctive name has been applied, together with many unnamed types, and the further culture of these forms at the Brooklyn Botanic Garden, where the work on which this paper is based was performed.

Among the plants so collected (comprising over three hundred separate accession numbers) only one plant of the Boston fern strain has been found which produces fertile spores. As this was of uncertain origin, and distinct from any of the named varieties of the florists' introduction, it has been designated by a new name, *Nephrolepis exaltata bostoniensis fertilis*[2]. In view of the variability of the Boston fern in vegetative reproduction, the possible behavior of this new form in spore cultures constituted a problem of considerable interest.

Accordingly, a first sowing of *fertilis* spores was made in 1917. New forms appeared by the wholesale. In a crop of about two hundred plants over forty were picked out as being capable of being differentiated as distinct types. Most of these have been kept under observation to the present time, and subjected to various methods of culture. Furthermore, five second generation cultures have been raised from fertile offspring of the plants of the first *fertilis* culture. It is the purpose of the present article to present a survey of the variation manifested in these several cultures by means of brief descriptions and by illustrations.

Characters and Origin of Fertilis

This form has already been briefly described and illustrated as a variety of problematical origin[3], adjudged on the basis of its appearance and behavior in variation to have arisen as a bud sport reversion from the horticultural form, *Piersoni*. Like *Piersoni*, it is typically twice pinnate but produces many once pinnate leaves. It has also the same size and habit of growth. It differs mainly in that it produces normal sporangia filled with well-developed spores, whereas *Piersoni* bears only aborted sporangia. Correlated with its fertility, it has a thicker leaf tissue and somewhat coarser growth. In this respect it differs from *Piersoni* in the same respects that wild *exaltata*, the species, differs from ordinary *bostoniensis*, which is also infertile.

The once pinnate leaves of *fertilis* appear indistinguishable from leaves of the feral type, just as the once pinnate leaves of *Piersoni* seem identical with the leaves of *bostoniensis*. It might be asked why *fertilis* should not be ascribed to *exaltata* as a direct pro-

*Brooklyn Botanic Garden Contributions No. 42.

gressive sport, rather than as a reversion from *Piersoni*. The answer is found in the behavior of *fertilis* in giving rise to numerous new forms, many of them similar in appearance to some of the bud sports of *Piersoni*. The wild species form seems to be stable. Neither in the field nor under rather extensive cultivation before 1895 when the Boston fern appeared to replace it as a florists' favorite, has it been detected in the production of new forms comparable with those which have developed from *bostoniensis*.

The case for referring *fertilis* to *Piersoni* as a reversion in fertility is different. As from *Piersoni* there have developed either directly or indirectly, dozens of new forms differing in size, division, and in other characters, so from *fertilis* spores, there have appeared a large number of new and distinct types, and many of these bear close resemblance to analogous varieties of *Piersoni* origin. *Fertilis* is thus interpreted as a possible bud sport from *Piersoni* in which the reversion has been from a condition of spore deficiency to one of normal viable spores, together with concomitant foliage differences noted.

It may also be noted that rumors are current among florists of two or three similar varieties from which spore cultures are said to have been obtained, with numerous new forms as a result. One variety, *Elmsfordi,* is reported as having arisen in a spore culture of *Whitmani,* a second generation bud sport of *Piersoni.* However, during the past ten years, no specimens of fertile plants of the Boston fern type have been seen in dozens of visits to fern growers widely distributed from Massachusetts to Ohio.

Culture and Characteristics of the Sporeling Plants Raised in 1917

Growth of Spores and Early Variation of the Sporophytes

The spores were sown in a pan of sterilized soil by scraping the sori from fertile pinnae; one or two entire pinnae were put in to help in the later identification of the cultures. The pots were kept covered with glass to avoid contamination. That this was prevented was indicated by the absence of plants of such common green-house plants as species of *Pteris* and *Adiantum,* which were always found in unprotected cultures. Germination was abundant, the surface of the soil becoming practically covered with the large prothallia (See Figure 8). In some cases the spores germinated *en masse* inside the sporangia, producing tufts of slender prothallia. Such germination occurred also in the sporangia still attached to the pinnae.

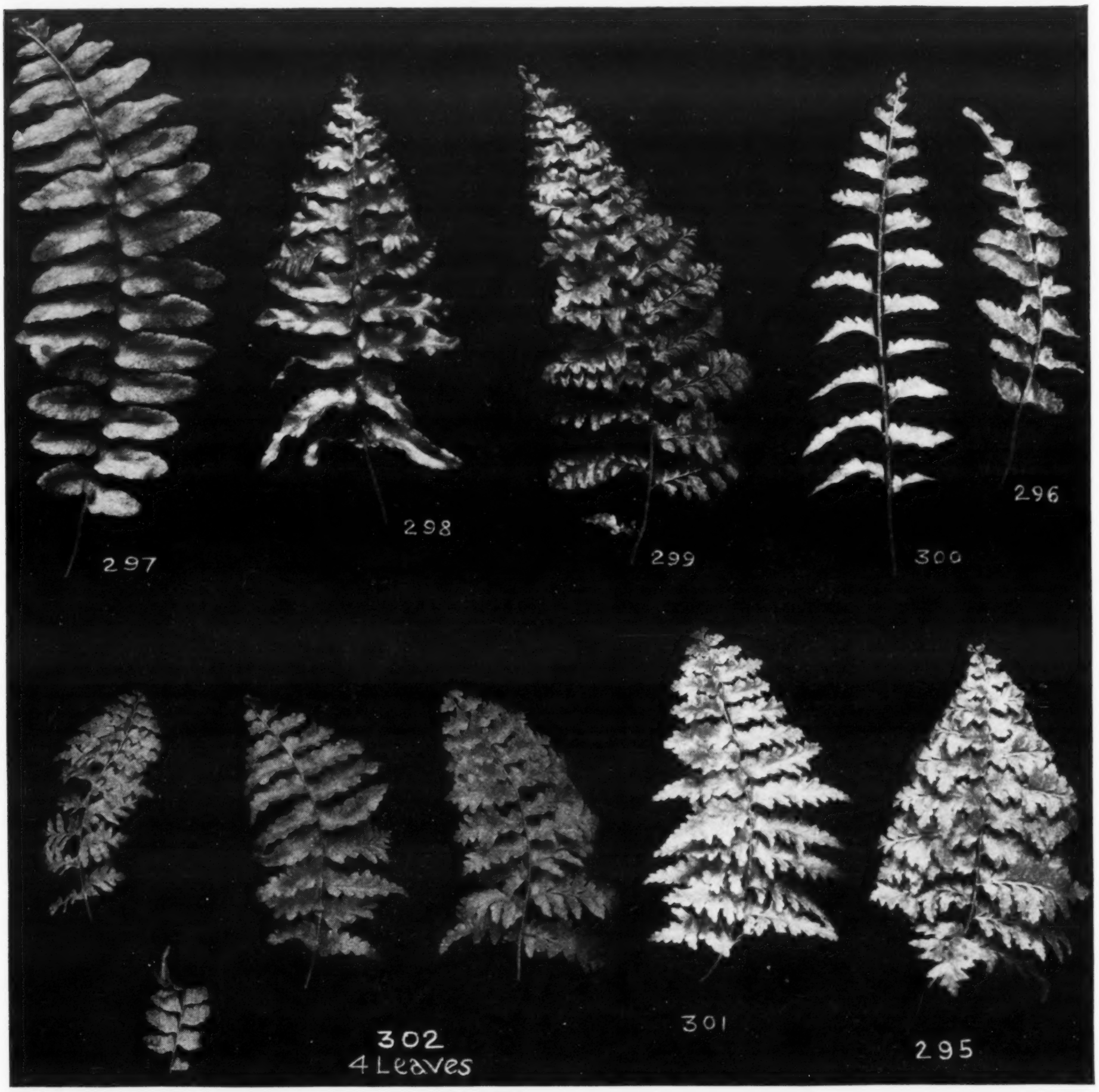
That variation was to occur was evident with almost the earliest leaves to appear on the young sporophytes. Even first leaves showed differences, which, on the basis of later experience, were probably indicative of the diversity of types. Succeeding leaves showed the differences even more clearly. For comparison, a sowing of the spores of a plant of *exaltata,* collected in Florida by Dr. John K. Small, was grown at the same time as the *fertilis* culture. In the *exaltata* pan, the young leaves appeared uniform from the first, showing none of the differences of the *fertilis* sowing. In Figure 8 are shown photographs of two spore pans which illustrate this point.

In the *fertilis* culture, as the plants grew older, the differentiation noted in the first leaves became accentuated, and other differences appeared. By the time of the fifth or sixth leaves, the foliar characters of the adult plants were usually well established. In Figure 9 are shown leaves of this stage, representing eight different plants, selected on the basis of the differences already manifested. These plants were nearly all grown to maturity and their characters as adult plants were found to have been indicated clearly, even to rather minor differences of leaf form.

Plants 297, 298, and 299 (Figure 9), were selected as already typically divided; respectively once pinnate

PROTHALLIA AND YOUNG SPOROPHYTES OF EXALTATA AND FERTILIS

FIGURE 8. Above is shown one of the five second generation sowings of the spores of *fertilis,* the fertile bud sport of the Boston fern. The variability in shape of leaves is similar to that in the original *fertilis* sowing, of which no photograph was made. Below is shown a culture of *N. exaltata,* the wild progenitor of the Boston fern. Note the uniformity of the leaves of these young plants as compared with the *fertilis* sowing.



VARIATION IN LEAVES OF EIGHT FERTILIS SPORELINGS

FIGURE 9. The numbers accompanying the leaves are the accession numbers of the plants in the Boston fern series at the Brooklyn Botanic Garden. The leaves are about the fifth or sixth produced by the young plants. Sporeling 297 is a stable once pinnate type, of coarse texture, like the wild parent of the Boston fern, *N. exaltata;* 298 is an unstable, partly twice pinnate form, similar to the original *fertilis* type; 299 is regularly twice pinnate; the pinnae of 300 are unsymmetrical, and those of 296 are defective and abortive, probably pathological. Four successive leaves of sporeling 302 are shown, to illustrate some of the variations in extent of leaf division characteristic of this plant. Sporeling 301 is regularly once pinnate, pinnatifid, with distinctively shaped pinnae, becoming twice pinnate when mature, and 295 is already twice pinnate, pinnatifid, even at this early stage.

(297), twice pinnate (299), and intermediate, partly once and partly twice pinnate (298). The adult plants of these numbers manifested exactly these characters in their leaves. The once pinnate form (297) developed into a fertile once pinnate plant superficially indistinguishable from wild plants of Florida extraction. Plant 299 continued stably twice pinnate when mature. Plant 298 showed at maturity a state of unstable leaf division essentially like that of the parent plant, *fertilis*. Instability of leaf division is further

illustrated by four leaves taken from a single young sporeling, No. 302. At maturity this number proved to be predominantly once pinnate, but always showed some twice pinnate leaves at the same time.

The other four leaves illustrated offer other variant features easily noted. Numbers 296 and 300 were not grown to adult condition, owing to accidental loss, but were obviously well marked forms. Plants 295 and 301, although differing in their early stages in rather inconspicuous characters, maintained these differences as adult plants in more evident form. Thus plant No. 301, picked out at this early stage because of its narrow, long-pointed pinnae, continued this character in mature state. (See Figures 12, 13, and 14.) Number 295, selected at first because it was completely twice pinnate and somewhat further pinnatifid, still produces leaves of this type. (See Figures 12, 13, and 14.)

Later Developments and Methods of Culture

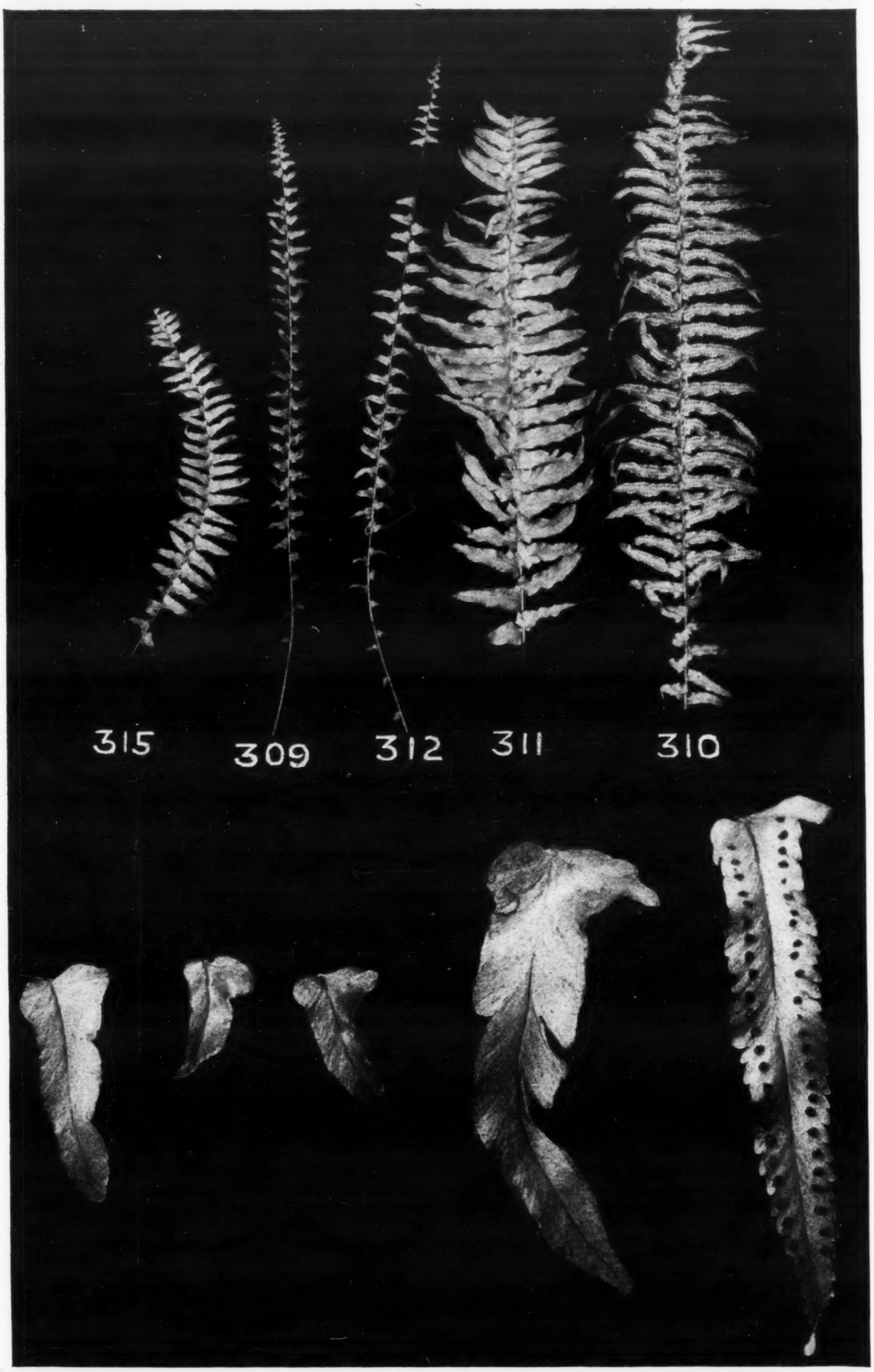
As the young sporophytes reached the five or six-leaved stage, they were pricked out into other pans for better growth conditions and to give the remaining sporophytes and prothallia in the crowded pans a better chance to grow. About one hundred and fifty plants reached this stage and were thus transplanted, later being potted separately as they increased in size. The spore pan still contained prothallia and was set aside for their further development.

Out of the first group of sporelings, the great majority proved to belong in about equal numbers to two types, either completely once pinnate like the form shown in Figure 9 (No. 297), resembling the species, exaltata, or more or less twice pinnate, tall and coarse, and thus like *fertilis*. These two types were not entirely uniform among themselves but they differed so slightly from each other that, owing to the exigencies of greenhouse space, they were later discarded, except for sample plants of each sort. Before they were thrown out, however, they had been given several months' culture, partly under glass, partly out-of-doors.

Twenty-five plants of this set were retained as sufficiently distinct *inter se* to justify separate accession numbers and more extended experimental culture. Later, sixteen additional numbers were added from the old spore pan as the remaining prothallia produced sporophytes, making a total of forty-one distinct types. The culture of these forms for several years showed that they possessed individual characters sufficient always to render their identification possible, but the original forty-one have been reduced at least one-half by the elimination of the less distinct forms and the occasional loss of a number.

The first set of twenty-five forms were given accession numbers in the regular series in which the entire collection of *Nephrolepis* had been listed, and these plants range in number from 290 to 320. The second, later set of sixteen forms were separately numbered from 75-1 to 75-16 respectively. A later culture of the spores of *fertilis* (No. 75) was started in 1921, and has been found to include additional distinct types. These have received a third series of numbers. Their description will be reserved for a later paper.

The types selected from the 1917 sowing have been subjected to various methods of culture designed to develop not only their characteristic leaf form and division, but also their habit of growth, fertility, runner production, disease resistance, etc. They have been given one or more periods of bench culture in open rich soil, favoring the fullest production of leaves and runners. The runner progeny have been grown comparatively in sets of half a dozen. Specimen plants have been given the best possible pot culture to determine the carriage of the leaves and the contour of pot bred plants. Their growth has been tested by one



LEAVES AND PINNAE OF ONCE PINNATE SPORELINGS

FIGURE 10. The accession numbers of the sporelings are given in the Figure. Natural sized pinnae from each of the leaves are arranged in the same order as the leaves above them. Note variations in the habit of growth. Of these sporelings three are fertile: 310, 311, and 315. The latter produced viable sporangia only after six years of culture.

or more periods of out-door culture under lath shade. At the same time, several collections of *exaltata* from Florida, plants of the original *fertilis*, and various forms of the Boston fern bud sports have been subjected to similar conditions.

It may be set down in advance that these sporeling comprise a wide range of variation, in some respects paralleling the variations of the bud sport series, in other respects showing entirely distinct characteristics. The long-continued culture, together with the different conditions supplied comparatively, have been valuable in establishing authentic bases of differentiation, and in modifying opinions formed as a result of more limited experience. For example, one form, No. 315, long considered sterile, has this past summer (1923) produced fertile leaves.

The most important method of experimental study has consisted in the raising of second generation sporeling crops from such of the first series of forty-one forms as have produced fertile spores. So far five such cultures have been brought to a point at which the results in variation may be described. Others are under way and one third generation sporeling culture will come to maturity in 1924.

Classification of the Mature Sporophytes According to Leaf Division

The various sporeling types may be most conveniently described on the basis of a classification according to leaf division, three degrees of which are represented in the 1917 culture, viz., once pinnate, twice pinnate, and thrice pinnate. No attempt will be made here to give complete detailed descriptions of individual forms, but rather the lines of variation will be indicated, together with the incidental description and illustration of significant varieties. Of the forty-one types originally selected as distinct, only two have developed thrice pinnate division, thirteen are once pinnate, and the remaining twenty-six vary about the twice pinnate state as a mean—some almost reaching the thrice pinnate condition while others are never more than once pinnate, pinnatifid.

The Once Pinnate Sporelings

Among the once pinnate forms there is marked variation along a number of lines: in length of leaf, from two to four feet; in breadth of leaf, from three to twelve inches; in the growth of the stem, whether erect and growing out of the soil, or short and inconspicuous; in the number of leaves per stem, in the number of stolons, in their production of new bud plants. The leaves differ in carriage, whether erect and stiff, or lax and drooping; whether with green, herbaceous petioles, or with the latter reddish, woody, often brittle. The pinnae vary in form, in contour, as ruffled or plane; in margins, whether entire or variously incised; in texture from thin and papery to relatively thick and leathery. In some types the pinnae are broad and overlapping; in others, narrow and distant. There is variation in fertility: some are abundantly fertile; others produce sori of small, brown, abortive sporangia; others have so far produced no sporangia at all. The most interesting of all the variant characters, the capacity for further variation, has so far been tested in only one once pinnate form, No. 307, and is described and figured later in the paper.

The characters of these once pinnate forms, as expressed in their leaves, are shown in Figure 10 and in other illustrations to be noted. In Figure 10 are shown a leaf and pinna of a dwarf once pinnate form (No. 315) which has in general the aspect of one of the bud sports of the Boston fern. It produces a bushy crown of spreading leaves, and seemed at first to be of possible horticultural value, but continued culture demonstrated a marked fault; viz., the fact that regularly some of the leaves fail to develop properly, aborting when about half size. Under poor cultural conditions, a majority of the leaves showed this condition, which has

since been described as due to a new species of fungus[4]. As noted above, this past summer, for the first time in six years, it has produced fertile leaves and a sowing has been made of the soral contents to test its heredity. If its progeny are all susceptible to fungus, the test is likely to be inconclusive.

In Figure 10 is illustrated a very distinct once pinnate form (No. 309), with numerous, very narrow leaves, two to two and a half feet long, with green herbaceous petioles. The plants grow vigorously, and produce numerous runner progeny (See Figure 14), but these as yet have shown no sori. The pinnae are strongly auriculate but otherwise very narrow, often irregularly flexed as shown in Figure 10, and with the margins irregularly incised. Another similar form (No. 312) usually has longer leaves, fewer per plant, and differs otherwise in growth characteristics.

The other two forms shown in Figure 10 are coarse, large-leaved, and fertile, approximating in many respects some of the wild types of *exaltata*. The plant numbered 311 is especially heavy in texture, with broad, overlapping pinnae, nearly all of which show the irregular erosion of the margins pictured in the natural-sized pinna. The margins are also often thickened or calloused. The last form shown in Figure 10 (No. 310), is tall and fertile, and agrees in superficial characters with common types of *exaltata*. Note the ruffling of the pinnae, together with their regular and distinct crenation.

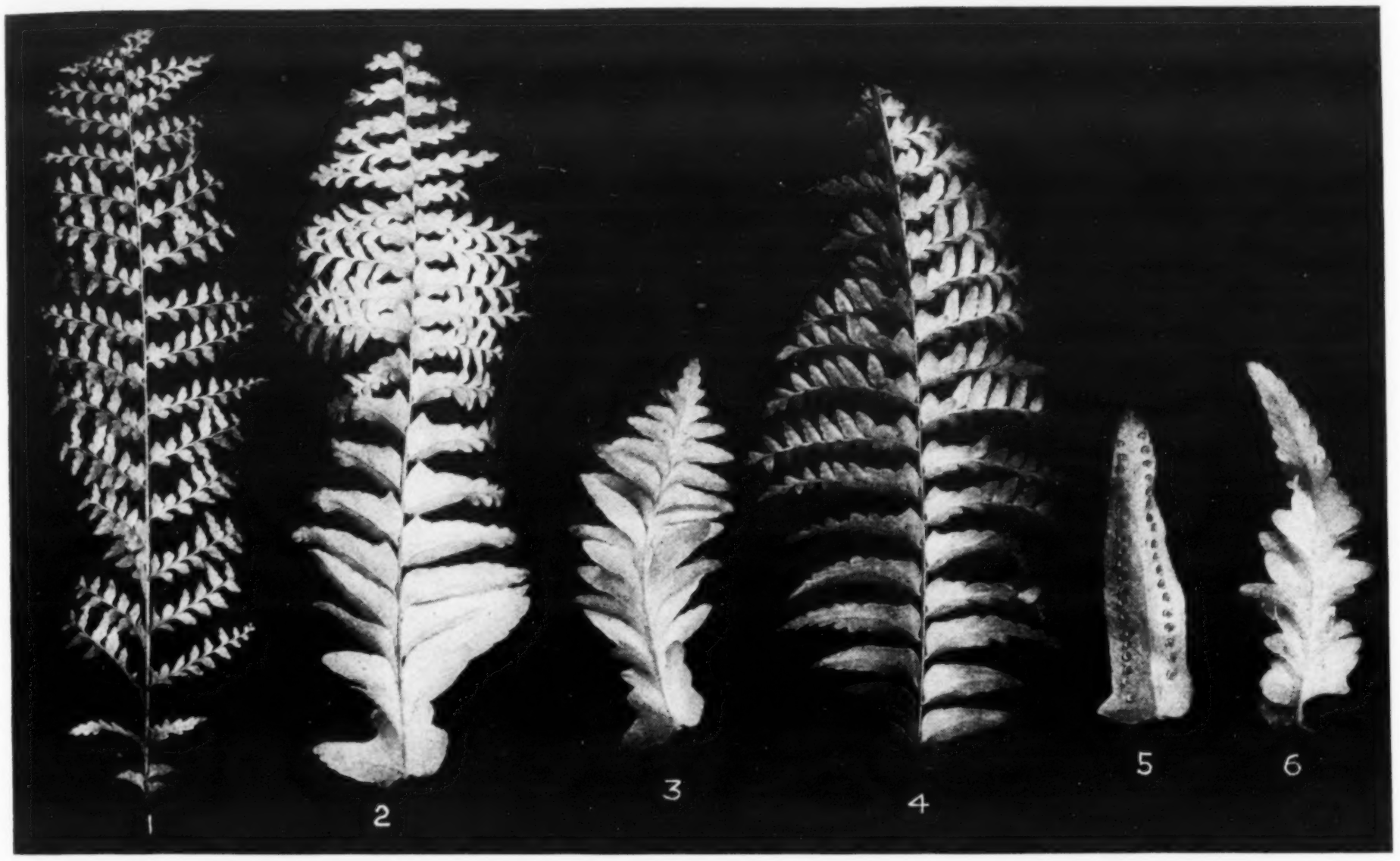
Four other once pinnate types are illustrated in Figures 12 and 13. Sporeling 307, shown in both plates, is a symmetrically developed, fertile type which is particularly interesting because its spore progeny has been raised and has proved to include a small proportion of twice pinnate plants. In other words, its superficial characteristics, as expressed in its once pinnate leaves, mask a capacity for twice pinnate progeny when its spores are grown. In Figures 12 and 13 is shown the largest of all the *fertilis* sporelings, represented here by a once pinnate leaf, but capable in its runner production, of developing twice pinnate plants. This form (No. 308) regularly throws runner plants with twice pinnate leaves, but when these plants are grown to a large size, the double division is lost as the leaves develop in size. The pinnae of No. 308 are long, narrow, and ruffled, and usually recurved or deflexed (See Figure 13).

Sporeling number 314 (Figures 12 and 13), is another type which approximates the wild forms, but with persistently distinct individuality as expressed in size, growth, habit, shape and contour of pinnae, etc. Form No. 75-1 (Figures 12 and 13) is a dwarf, fertile type with regularly reflexed pinnae, somewhat like those of the horticultural form, *Scotti*.

Characters of the Thrice Pinnate Sporelings

Among the twenty-eight distinct *fertilis* sporelings which are more than once pinnate, there is great range in variation and along lines similar to those described for the once pinnate types: viz., in size and growth characteristics, in disease resistance, in number of leaves per crown, in the shape, size and contour of the pinnae and of the smaller divisions. In division they vary from once pinnate with slightly pinnatifid pinnae (See Figure 16, No. 11) by slight steps to strictly twice pinnate forms, and further to forms which are more or less thrice pinnate. The words "more or less thrice pinnate" are used advisedly because, although two forms have achieved this grade of division, they show at the same time leaves of a lower degree of pinnation. Some of these forms are extremely stable in their division types, others most unstable. In some the instability manifests itself mainly in separate leaves; in others, every leaf may be a partly once and partly twice pinnate (See Figure 12, No. 75-2).

The pinnae of the thrice pinnate



TRIPLE DIVISION OF LEAVES IN TWO SPORELINGS

FIGURE 11. 1, pinnae of the cultivated variety, *Whitmani;* 2, sporeling 293, showing triple division; 3, same, showing double division; 4, sporeling 320, showing triple division; 5 and 6, same, pinnae taken from a single leaf showing single and double division. The triple division appears only in large plants, under favorable conditions of culture, and none of the sporelings so far raised have all leaves triply divided.

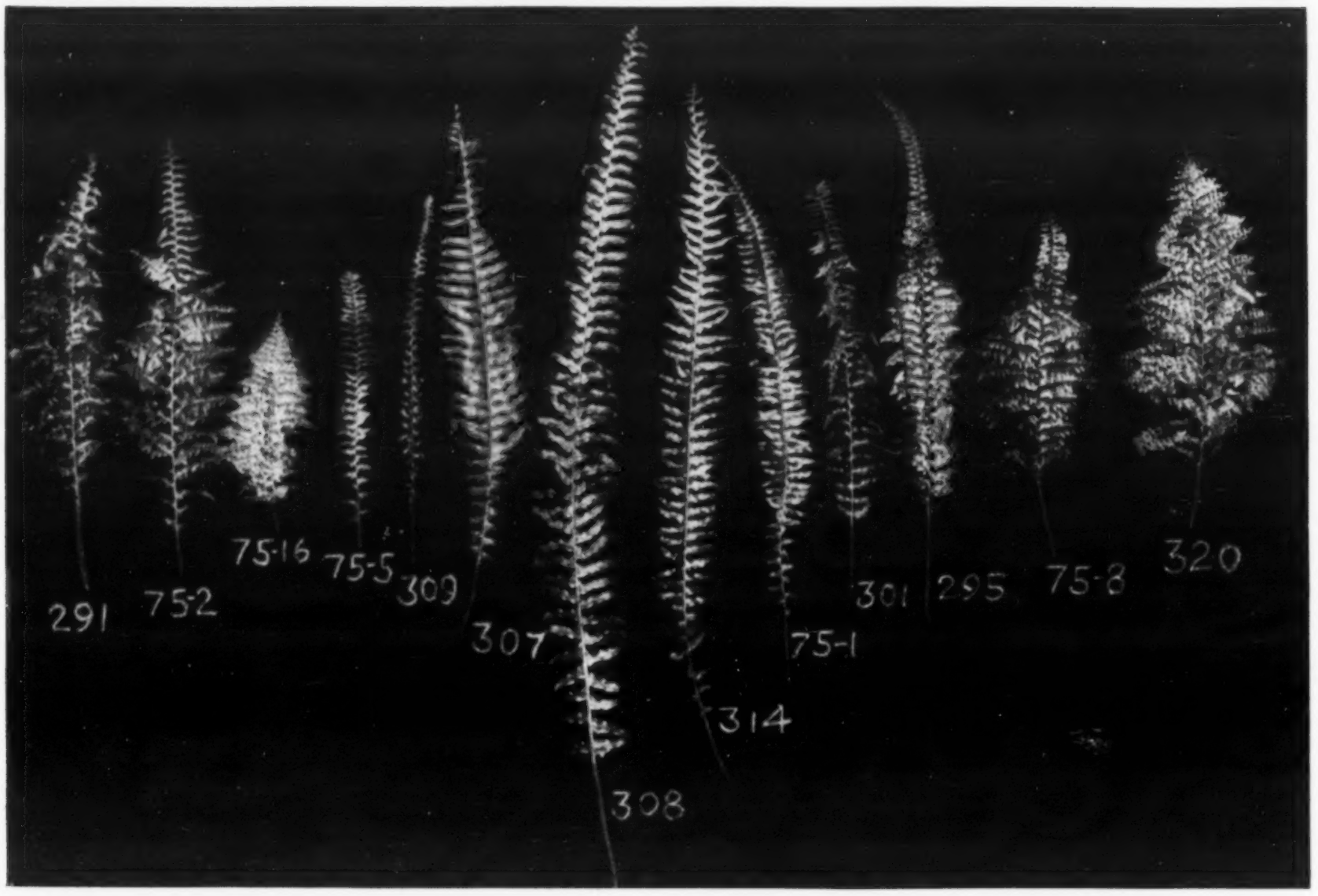
sporeling forms are illustrated in Figure 11, together with a simple pinna of a thrice pinnate bud sport of *bostoniensis*, *Whitmani* (No.), for comparison. It is interesting to recall that *Whitmani* is a second generation bud sport from *Piersoni*, and that these 1917 sporelings of *fertilis* bear a similar (second generation) relation to *Piersoni*, if the antecedents of *fertilis* have been correctly interpreted.

Both the thrice pinnate sporeling forms, Nos. 293 and 320, are coarse, fertile types in which the triple division is reached only after the leaves have attained an advanced size, and often only in part on the leaves. In form No. 293, many of the leaves are usually similar to those of *fertilis*, that is, either once or twice pinnate. Nos. 2 and 3 of Figure 11 represent the thrice and twice pinnate forms of the pinnae respectively.

In form No. 320 the triple division is ordinarily more frequently developed than in No. 293, but it may be entirely absent under conditions of poor culture, even in mature plants. Thus, while one plant may manifest the three pinnate condition in all its leaves, another may be entirely twice pinnate. No. 4 (of Figure 11) shows a pinna with a partial development of the triple division which is still better shown in Figure 13. Numbers 5 and 6 of Figure 11 are from a single leaf of No. 320 in which no evidence of triple division was expressed. Well developed sori with normal sporangia are produced frequently on all three types of pinnae. The sporeling progeny of No. 320 are described in the second part of this article.

Characters of the Twice Pinnate Sporelings

Representative twice pinnate sporelings are illustrated in Figures 12 and 13, where seven leaves of this type are shown, together with the six once and



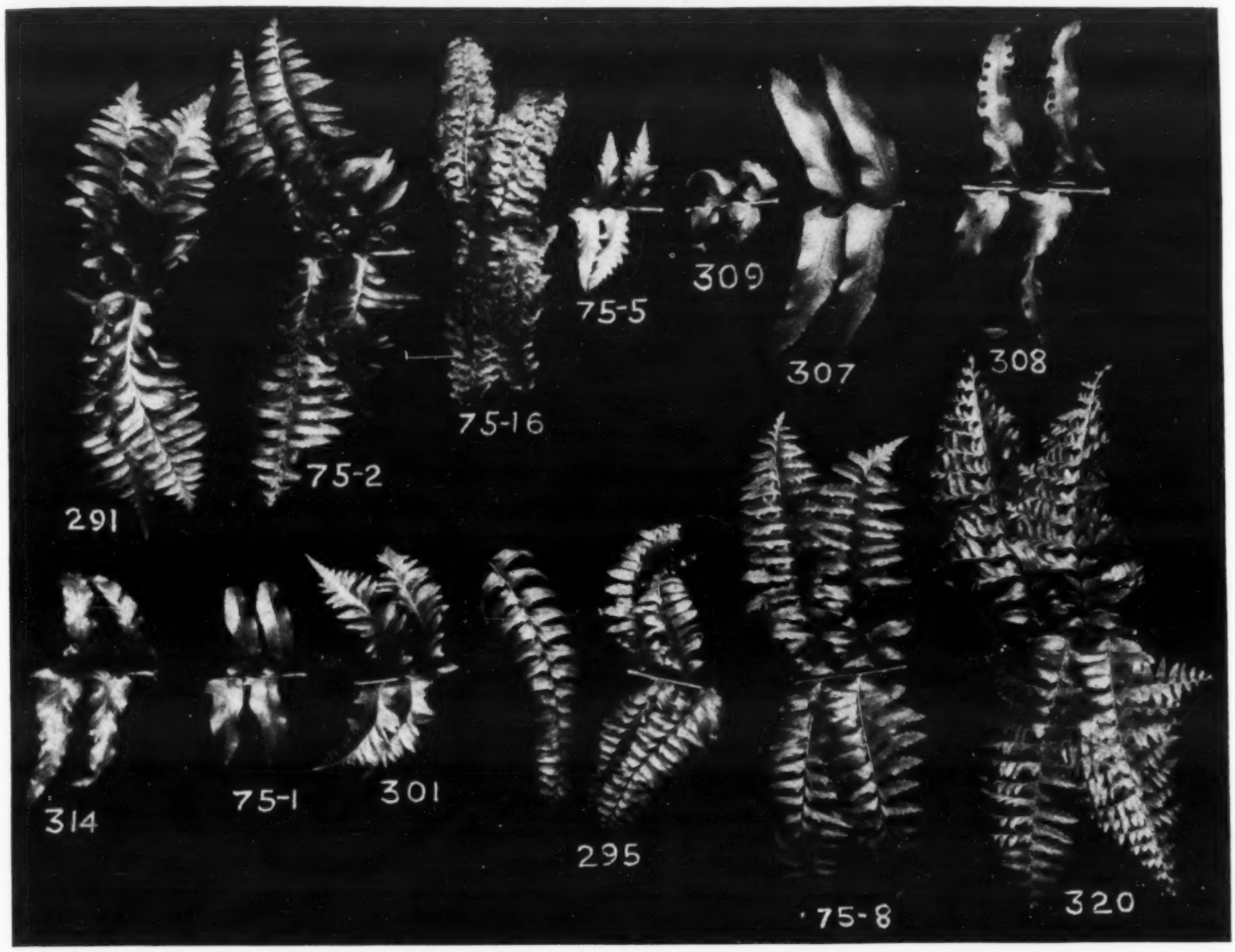
RANGE OF VARIATION OF LEAVES OF FERTILIS SPORELINGS

FIGURE 12. The accession numbers of the sporelings from which these leaves were taken are given here and in Figure 13, where portions of the leaves are shown in detail. The leaves of 308, the largest of the *fertilis* sporelings, reach a length of four feet.

thrice pinnate forms already mentioned. These thirteen leaves were taken from well-grown pot plants (See Figures 14 and 15) and furnish a good basis for distinctive size comparison, as well as indicating other differences.

In both Figures 12 and 13 is illustrated a large, coarse, twice pinnate form (No. 291) essentially like the original *fertilis* in its characters. In Figure 16, two pinnae of the same number were shown (Nos. 10 and 11) which illustrate the variation in division between the once and twice pinnate condition. At first sight 75-2 (Figures 12 and 13) is essentially like the preceding in division, differing merely in the perhaps accidental irregularity of the outline of the leaf, which is partly once and partly twice pinnate. This irregularity, however, manifests itself in practically all the leaves of this form, and, as will be shown later, is present also in the second generation progeny as an inherited character. It may be observed that the pinnae are somewhat revolute and that the leaves have a more erect habit than those of No. 291 (See Figures 13, 14, and 15).

Sporelings 75-16 and 75-8, illustrated in Figures 12 and 13, have leaves which are typically twice pinnate, pinnatifid. The first form (No. 75-16) is the smallest of the whole 1917 series of *fertilis* sporelings. Its leaves are never more than eighteen inches long, full and plumy, with overlapping pinnae and segments, and strongly suggest some of the cultivated bud varieties, such as *elegantissima-compacta*, a first generation sport of *Piersoni* (See Figures 12, 13, and 14). In its habit, however, this sporeling is different from the horticultural forms, as the leaves spread laterally. The petioles are brittle and the pinnae are usually strongly reflexed. The other twice pinnate, pinnatifid form (No. 75-8) may reach two feet in the length of its leaves, which are coarser, tougher, more erect, and with



DETAIL OF LEAVES SHOWN IN FIGURE 12

FIGURE 13. Other leaves of 291 are shown in Figure 16, as this plant varies remarkably in extent of leaf division. Two pieces of the leaf of 295 are shown, one of them being the entire tip of the leaf, which is completely unrolled, a most unusual condition, not only among the varieties of the Boston fern, but in the entire genus *Nephrolepis* as well.

larger segments (See Figures 12, 13, and 14).

Another interesting pair of forms to be described comparatively (Nos. 295 and 301) are also illustrated in Figures 12, 13, and 14. This is the pair already shown in the form of immature leaves in Figure 9 as two rather similar leaves. The first form, No. 301 (Figures 12, 13, and 14), is a strong-growing medium-sized plant with erect, rigid, narrow, dark green leaves, with reduced basal pinnae. The pinnae shown are characteristic in form and division, tapered apically and basally, and completely twice pinnate only in the middle. The tips of the leaves of this number are always incompletely developed.

The second form, No. 295, also has narrow leaves, but these are pale green, more herbaceous, with green petioles, and somewhat spreading in habit. The apices of these leaves are not infrequently completely unrolled, a most unusual condition, not only for varieties of Boston fern, but for the whole genus, *Nephrolepis*, as well (See Figures 12 and 13). The revolute pinnae are usually broadest at the base and are more completely subdivided than those of No. 301. Small sori with defective sporangia are all that have been noted on No. 295 so that its characteristics cannot be further tested in a second generation. No. 301, however, is fertile, and on account of its progeny is contained in later pages.

HABIT OF GROWTH OF FERTILIS SPORELINGS

FIGURE 14. Leaves and pinnae of these are shown in Figures 12 and 13. All plants in this and the succeeding figure are photographed in the same scale. Second generation sporelings were raised from four plants shown here—320, 75-2, 301 and 307.

Variation in Susceptibility to Disease

The remaining form (No. 75-5) illustrated in both Figures 12 and 13, is representative of an additional line of variation, that of extreme susceptibility to disease. This feature has already been referred to in connection with the once pinnate form. No. 315, but the susceptibility is much more pronounced in this once pinnate, pinnatifid type, and in two other similar varieties not illustrated. Indeed, so frequent is the infection in these three plants that it is doubtful whether their leaves have ever been produced in a fully matured form. They have been given a variety of cultural conditions during their six years of cultivation in the hope that some environment might be found under which they could resist the fungus infection and develop normally. The best development has been attained during the past summer when one of these forms has produced leaves twenty inches long. In texture the leaves are coarse and such as might be expected to produce normal sporangia, but this has not yet been accomplished. Under conditions of bench culture, with a superabundance fo moisture, one of the forms degenerated to a condition of a few dying crowns, all the leaves and some of the stolons being blackened and aborted. Repotted and given abundant air and little water, the form revived but did not reach freedom from infection.

With the thought that the particular section of the stock bench where these three types had been growing might

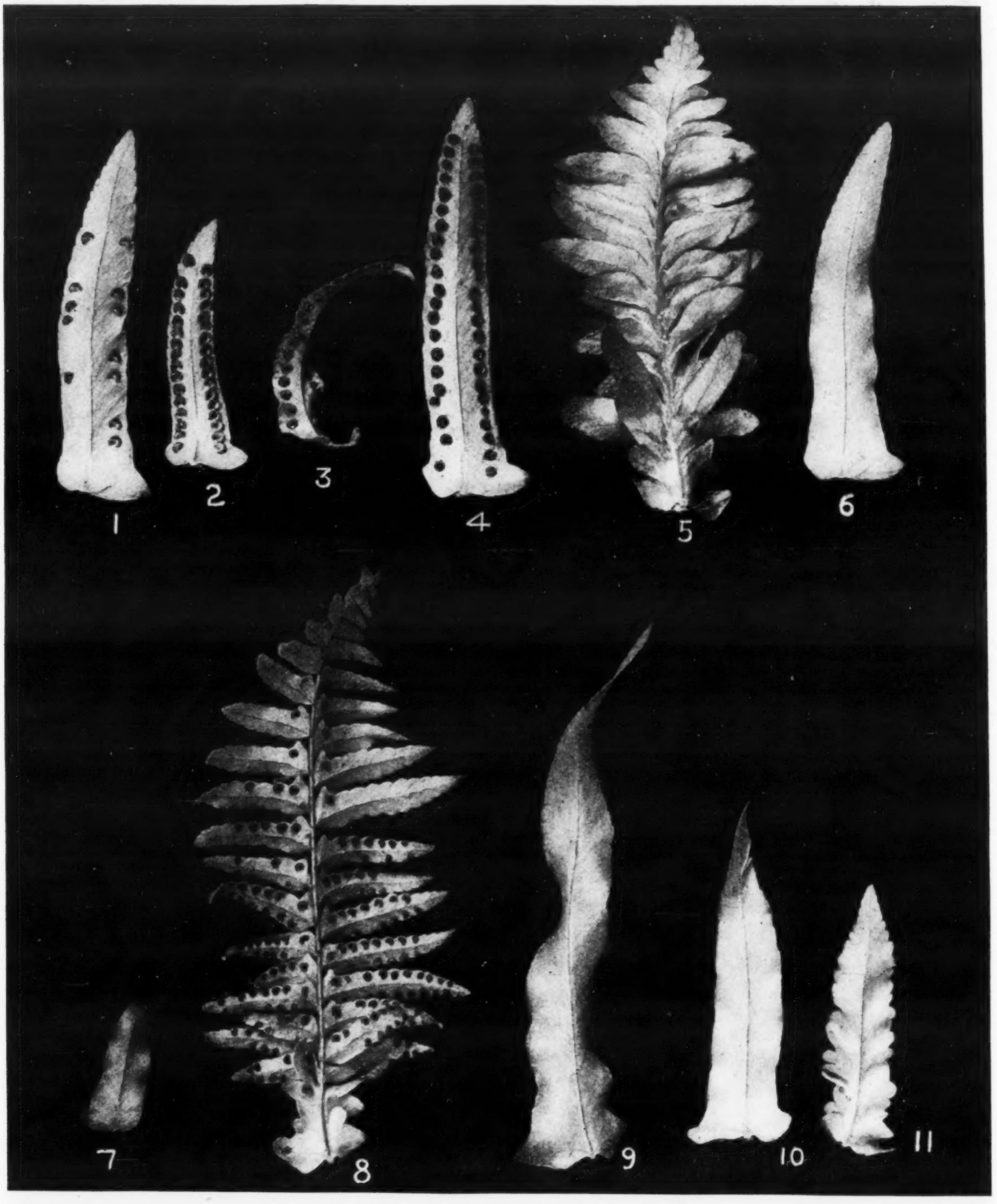
FERTILIS SPORELINGS AND PLANTS OF EXALTATA

FIGURE 15. The two plants of *N. exaltata* are particularly well grown specimens, for when grown in pots this species rarely produces so many leaves. The differences between the two *exaltata* plants in habit of growth, form of leaves, etc., have been constantly maintained during at least seven years of experimental culture.

have been originally infected, they were taken out and replaced by three small, healthy runners of a vigorous sporeling type, No. 308. These proved, however, entirely immune under these circumstances, demonstrating that the susceptibility of the other three forms had been a real constitutional characteristic, a matter of variation and difference from their sister sporeling types. It may be noted that plants of *fertilis* itself have been observed suffering from this tip-rot. The condition of the three diseased sporeling types was merely one of greater susceptibility than that of *fertilis*, that of the other sporelings, of less susceptibility.

Variation by Vegetative Reversion

Another type of variation noted in the division forms of *fertilis* sporelings is a tendency on the part of some



PINNAE OF EXALTATA AND OF BUD SPORTS OF THE BOSTON FERN

FIGURE 16. The first three pinnae are from plants of *N. exaltata*—1, from Florida (318); 2, from Porto Rico (52); 3, from Florida (316); 4 and 5 are pinnae of *fertilis;* 6 is a pinna of the Boston fern; 7, of the horticultural variety, *Giatrasi;* 8, of an unnumbered sporeling of *fertilis,* very similar to *fertilis* itself; 9, of the horticultural variety *Harrisi;* and 10 and 11 are pinnae from sporeling 291.

to revert to a once pinnate condition through bud variation, a tendency of frequent occurrence among the bud sports of *bostoniensis*, and described at some length in an earlier paper already cited[1]. It is not possible to present any conclusive evidence regarding the reversion of these sporeling types, owing to the small number of plants of any particular form which it has been possible to grow. Space is available for only a few plants of each variety—at present they are reduced to one plant of each of the sporeling forms, and some have been lost or discarded since the photographs for the illustrations of this article were made. However, one twice pinnate form, not illustrated here but like No. 75-8, has given rise to once pinnate plants by bud variation several times, and one of these reversions seems to be stable in the once pinnate form. There is thus added to the series of *fertilis* forms raised from spores, another distinct plant derived as a bud sport.

Variation in the Habit of Growth

The variations in the habit of growth among the sporelings have already been referred to in connection with the descriptions of individual forms. These differences can be more fully appreciated comparatively by reference to Figures 14 and 15 in which fourteen mature plants are shown, all photographed at the same scale. The leaves in Figures 12 and 13 were taken from this group of plants.

The forms illustrated were selected not only because they present a wide range of distinct habit types, differences in size, carriage and number of leaves, etc., but also to include the four *fertilis* forms from which second generation spore cultures have been raised. With these are shown two plants of *exaltata* from Florida collections, photographed at the same scale. The differences which may be noted between these two feral strains in size, leaf, form, carriage, and in the shape and contour of the pinnae have been constantly maintained through at least seven years of experimental culture. These two plants are particularly well grown specimens. Ordinarily the wild types do not produce so many leaves in a single pot.

Sporelings of Fertilis Compared with Forms of Exaltata

It has been noted earlier in this paper that these *fertilis* sporelings have been grown comparatively with plants of *exaltata* and of various buds sports of *bostoniensis*, and that the sporelings comprise on the one hand, forms similar to some of the named varieties of the Boston fern, and, on the other hand, types indistinguishable from plants of the species as it occurs in the wild. An extended comparison will not be attempted in this article. The Boston fern varieties are too numerous; their characters and variation may be learned by reference to the descriptions and illustrations in the earlier papers already cited. Moreover, this first culture of *fertilis* does not furnish adequate representation of the possibilities of variation in this form; the capacity for variation can scarcely be exhausted by a crop of only two hundred plants as compared with the many millions of plants of Boston fern bud sports raised in the twenty-five to thirty years since its first recognition.

With respect to *exaltata*, its types also are insufficiently known. Extended field observation, together with the experimental growth of variant types, is desirable. Two of these have already been commented upon and illustrated in connection with the discussion of variation in the habit of the sporelings (See Figure 15, Nos. 206 and 289). In Figure 16 are shown the pinnae of three other numbers which differ consistently in leaf form as represented and also in other respects. The form shown in No. 1, Figure 16, is from Florida, and agrees in its characteristics with the other Florida specimen shown in Figure 15. In No. 2, Figure 16, is shown the pinna of a

Porto Rican plant of *exaltata* which differs regularly from the preceding, not only in the size and form of its leaves and pinnae but also in growth characters. No. 3 illustrates a particularly aberrant Florida plant. The pinnae are all strongly recurved and ruffled as indicated. Sporeling types analogous to these three wild variants have already been shown.

Other forms are shown comparatively in Figure 16. A single pinna of *fertilis* which matches the *exaltata* pinna of No. 1 is shown in No. 4, together with a pinna of ordinary Boston fern (No. 6). In No. 5 is shown a sterile pinna of *fertilis*, while in No. 8 is a fertile pinna which might have come from the same leaf but is really from an unnumbered sporeling plant. Two other bud sport types are represented in Nos. 7 and 9, respectively a blunt pinna of the dwarf variety, *Giatrasi*, and the slender, ruffled pinna of the largest of the bud sports, *Harrissi*. Somewhat similar forms among the *fertilis* sporelings have already been shown.

In general, it may be noted that while the *fertilis* series of forms comprises a wide variety of types, paralleling in many respects the Boston fern bud sports, they do not present in this first culture the extremes of size and division variation found in the other group. There are smaller varieties among the bud sports than have yet appeared from spores. It is interesting that as yet no crested variety has appeared. It seems probable from present indications that in a sufficiently large number of sporeling plants, practically every type of variation known among the Boston fern bud sports might be expected, though not necessarily in identical forms, but that the division types would not exceed the thrice pinnate conditions. In addition, there have already appeared a variety of distinct types not found among bud sports, but as these generally present some indication of horticultural deficiency, it is possible that similar types may have appeared in florists' establishments and have been discarded as valueless.

(*Concluded in October Number*)

Literature Cited

[1](*a*) *Bull. Torrey Club* 43:207-234; (*b*) *Am. Jour. Bot.* 9:140-157; (*c*) *Genetics* 8:75-95.
[2]*Am. Jour. Bot.* 9:147.
[3]*Am. Jour. Bot.* 9:147, pl. 5 and 6.
[4]Faris, *Mycologia*, 15:89-95. 1922.

BLUE & WHITE COLOR IN SWINE

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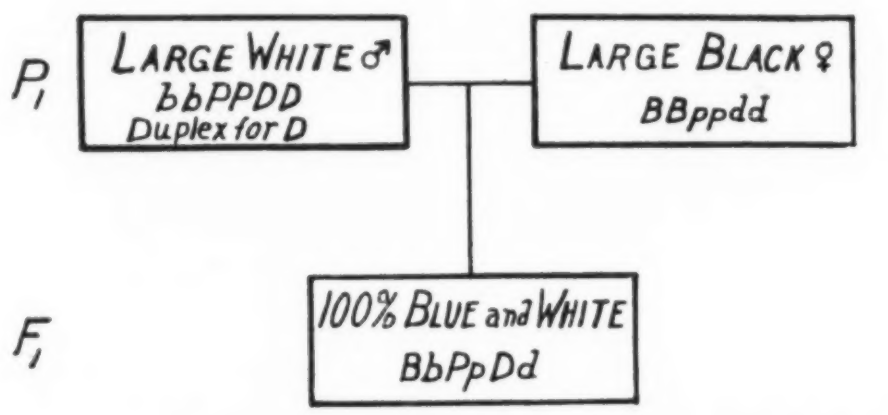
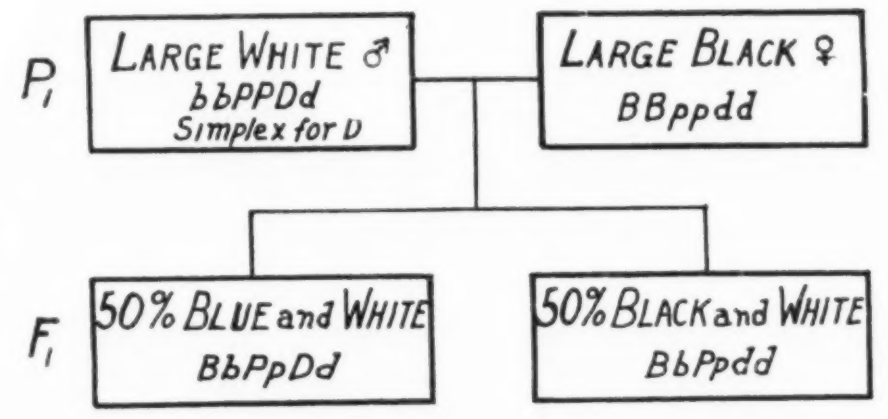
IN CERTAIN parts of England the pronounced heterosis exhibited by the progeny of the mating Large White × Large Black is well recognized, and the cross is commonly made for the production of an early maturing profitable pig. Usually the Large White boar is used on Large Black sows and the offspring are the much esteemed Blue-and-Whites. The breeder regards the heterosis displayed as being the peculiar property of pigs of this color (cf. the Blue-Grey cattle out of White Shorthorn ♂ and Galloway ♀) and is not prepared to grant that the blue may be but one aspect of the general Heterozygosis. He therefore looks upon the Black-and-Whites exceptionally included in the progeny of this mating as being inevitably inferior, though this question has never been examined critically. In one case recently examined a pure-bred Large White boar mated with seven Large Black sows sired in each litter Black-and-Whites; the proportion of Black-and-Whites to Blue-and-Whites in each litter was approximately 1:1 (40—60% of Black-and-Whites). Each class included males and females in more or less equal numbers. The father of the Large White, when mated similarly, had never thrown a Black-and-White.

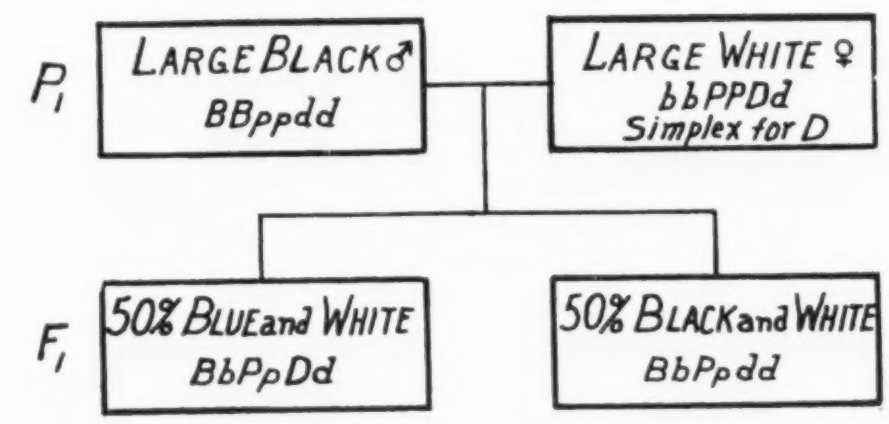
The reciprocal cross, Large Black boar on Large White sow, has been made but infrequently and yielded a proportion of Black-and-Whites. The cross therefore has not been extensively used, but in the records there is no evidence whatsoever that the offspring are in any way inferior to those of the other mating. "They have perhaps rather more black about them than when bred the other way" is the only comment upon the difference.

There is no suggestion of a sex-linked or sex-limited mode of inheritance. The relative proportions of color and white differ in different individuals. The depth of the black color varies. The facts, insofar as they are known, can be accommodated by the following tentative scheme:

B = the factor for black; b = that for white; P=that for the parti-colored condition, restriction of color —probably multiple factors are concerned). D=a dilution factor turning black into blue. The following chart shows the percentage of offspring produced by the various matings:







The results of the reciprocal crosses seem to indicate that the Large White sows used in these few cases were individuals simplex for the dilution factor.

In order to avoid the undesired Black-and-White it would seem that the breeder of Large Whites must mate all his herd to individuals of the contrasted color and discard all sires and dams that in such matings produce Black-and-Whites. The problem is the elimination of the individual simplex for the dilution factor.

So little is known of the genetics of the pig that it is thought desirable to record this note. It is of interest to note that the breeder assumes linkage between blue and characters of economic value.

Another Statistical Fallacy

DIE FRUCHTBARKEIT DER CHRISTLICH-JUDISCHEN MISCHEHE, von Dr. Max Marcuse. Abhandlungen aus dem Gebiete der Sexualforschung Band II, Heft 4 (1919-20). Pp. 20, price $0.15. A. Marcus and E. Webers Verlag, Bonn.

In the literature regarding racial hybridization, a common assertion is that mixed marriages are less fertile than those within a single race. Figures from Germany have often been cited to support this view. Prinzing, studying the fertility of marriages in Prussia, 1875-1900, arrived at the following averages:

Nature of Mating	*No. of Children*
Catholic × Catholic	5
Evangelical × Evangelical	4
Jewish × Jewish	3.8
Catholic × Evangelical	3.1
Christian × Jewish	1.7

At first sight it would appear that marriages between Christians and Jews showed a low fertility, "as if Nature itself revolted at such a mating." Other data, interpreted in the same way, will occur to all eugenists.

The indefatigable Dr. Marcuse has analyzed the situation in Germany and demonstrated, I believe, to the satisfaction of any disinterested person, that the low fertility of this type of mating cannot be ascribed to biological reasons.

In the first place, it is largely due to statistical fallacies: for instance, the parents are described as of different creeds, in each birth certificate; but after the first child or two it is quite likely that one will adopt the religion of the other, whereupon that particular marriage ceases to be included among the mixed matings, although the same couple may go on to have half a dozen more children.

In addition to other statistical fallacies involved, there is some real diminution of the birthrate, Dr. Marcuse thinks, but he explains this on psychological grounds, due to the economic status of the parents, and to other adequate causes.

The question of the results of racial hybridization is one of the most important now open for study. It is also one of the most confused, and it is highly desirable to have the underbrush cleared away as fast as possible. Dr. Marcuse's brief contribution is a welcome step in this direction. P. P.

HERITABLE CHARACTERS OF MAIZE

Polkadot Leaves*

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University of Maine

THE chlorophyl character described in this paper and called *polkadot leaves* was first found in the progeny of an inbred strain of Boone County White maize. The plants affected are normal green until about the time the tassel makes its appearance, when the margins of the leaves gradually become yellow. The yellow color spreads inwards towards the midrib, more in some leaves than in others, and in some cases covers the entire leaf. Within the yellow areas are small spots of green tissue, producing the polkadot pattern shown in Figure 17. In extreme cases the entire leaf is affected, but more commonly the basal part of the leaf has marginal bands of the polkadot pattern, while the distal part of the leaf is patterned throughout. This character makes its appearance on about the sixth leaf and becomes more and more pronounced on the upper leaves.

Plants with polkadot leaves seem to make a normal growth and produce ears which are apparently as good as those of their green sibs. The patterned leaves have a tendency to dry prematurely. The chlorophyl character, polkadot leaves, is inherited as a simple Mendelian recessive, and the factor responsible for its expression has been designated by *pk*.

Inheritance of Polkadot Leaves

The cross *polkadot* × *green* does not always give the same results. The F_1 plants from most of the crosses made were green with no apparent trace of the polkadot pattern. In a few crosses the F_1 plants had leaves with a very slight but distinct polkadot pattern. In some such progenies all of the F_1 plants showed the pattern in the heterozygous condition, while in others the pattern was apparent in some of the plants only. Evidently the expression of the character is influenced by other factors.

The majority of the F_2 progenies observed consisted of green and polkadot leaved plants in the ratio of 3:1. In Table I are listed four F_2 progenies with a total of 458 green and 159 polkadot plants. This is a deviation of 5± 7.25 from the expected numbers. In Table II are given the results of two progenies which deviated widely from the numbers expected for a 3:1 ratio. Apparently some plants heterozygous for polkadot leaves were classified as green, and some as patterned. The deviation of 85± 5.10 is surely significant.

Linkage Relations of Polkadot Leaves

The progenies listed in Table I also segregated aleurone color and the results are such as to indicate a close linkage between *pk* and one of the aleurone color factors. The progenies recorded in Table III segregated colored and colorless kernels in the ratio of 9:7, thereby indicating that two aleurone color factors are concerned. The deviations between the numbers observed and the numbers expected, assuming independent inheritance of *pk* and the factors for colored aleurone are quite wide and doubtless significant, X^2 having a value of 68.73. By assuming a linkage between *pk* and one of the aleurone factors, with two per cent crossing over, the observed numbers are in fairly close agreement with the numbers expected in each class, as shown in Table III. The value of X^2

*The investigation reported in this paper was made in connection with genetic studies of maize in the Department of Field Crops, Missouri Agricultural Experiment Station.

Table I

F_2 Progenies from the Cross Green X Polkadot

Pedigree	Green	Polkadot	Total
3308-2	54	21	75
3310-8	143	47	190
3310-9	133	50	183
3314-3	128	41	169
Totals observed	458	159	617
Expected (3:1)	463	154	617
Deviation	- 5	+ 5	

Table II

F_2 Progenies from the Cross Green X Polkadot

Pedigree	Green	Polkadot	Total
3309-2	67	66	133
3311-8	77	95	172
Totals observed	144	161	305
Expected (3:1)	229	76	305
Deviation	- 85	+ 85	

Table III

F_2 progenies segregating colored aleurone and polkadot leaves

Pedigree	Colored aleurone		colorless aleurone	
	Pk	pk	Pk	pk
3308-2	35	3	19	18
3314-3	93	3	35	38
Totals observed	128	6	54	56
Expected numbers, assuming independent inheritance of pk and the aleurone color factors	103	34	80	27
Deviation from observed numbers	+25	-28	-26	+29
	X^2 equals 68.73. P equals .C00000			
Expected numbers, assuming linkage between pk and one of the aleurone color factors, with 2 % crossing over	135	2	47	60
Deviation from the observed numbers	- 7	+ 4	+ 7	- 4
	X^2 equals 9.67. P equals .0221.			

Table IV

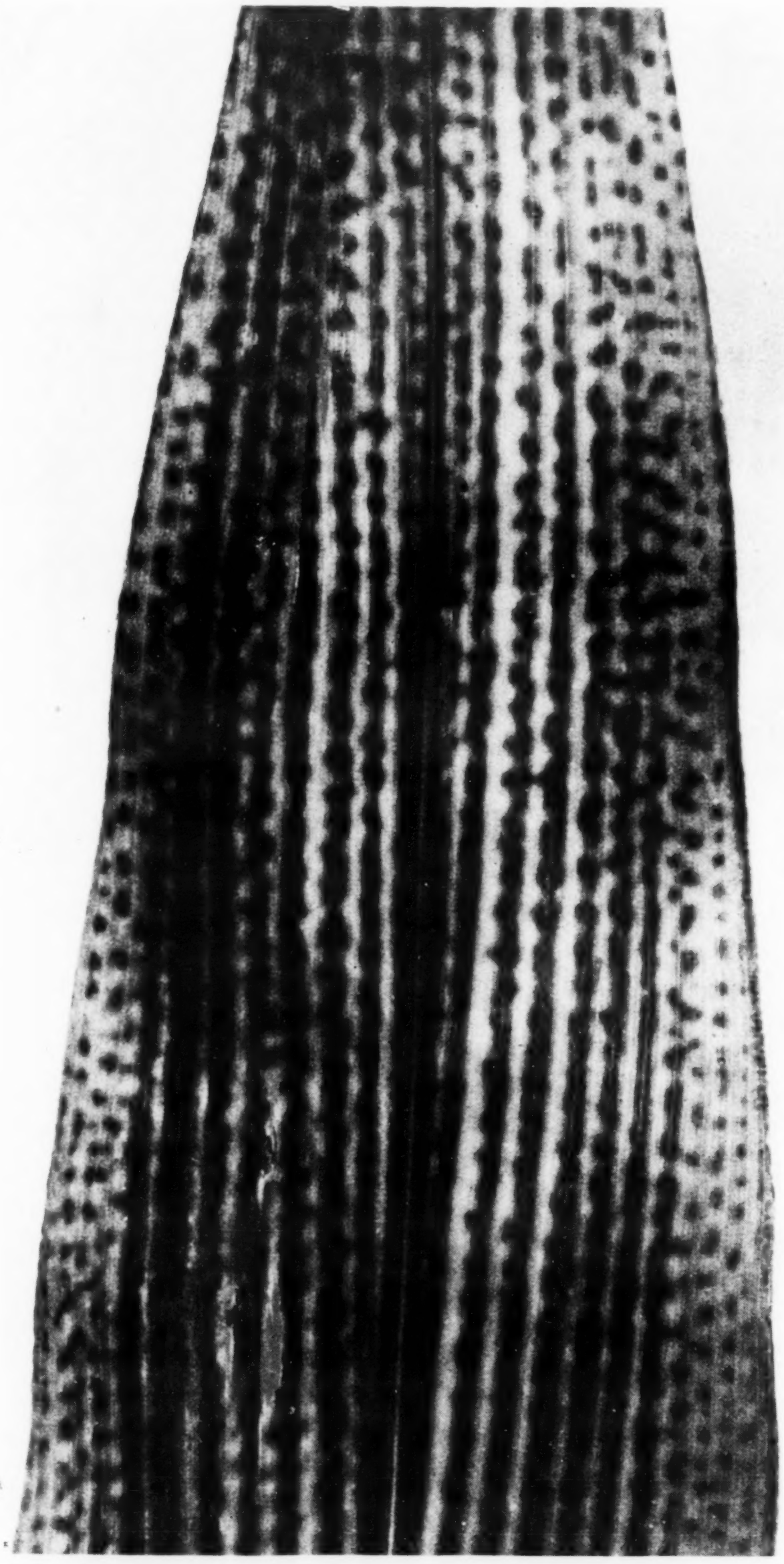
F_2 progenies segregating colored aleurone and polkadot leaves

Pedigree	Colored aleurone		Colorless aleurone	
	Pk	pk	Pk	pk
3310-8	71	3	72	44
3310-9	77	2	56	48
Total observed	148	5	128	92
Expected numbers, assuming independent inheritance of pk and the aleurone color factors	118	39	149	67
Deviations from observed numbers	+30	-34	-21	+25
	X^2 equals 49.56 P equals .000000			
Expected numbers, assuming linkage between pk and one of the aleurone color factors, with 2 % crossing over	156	2	124	92
Deviations from observed numbers	- 8	+ 3	+ 4	0
	X^2 equals 5.04 P equals .1718			

Table V

F_2 progenies from the cross, polkadot X shrunken

Pedigree	Non-shrunken		shrunken	
	Pk	pk	Pk	pk
3308-2 (X)	43	20	11	1
3314-3 (X)	97	41	31	0
Corrected for poor germination of shrunken kernels				
3308-2 (X)	43	20	19	2
3314-3 (X)	97	41	41	0
Totals, as corrected	140	61	60	2
Expected numbers for independent inheritance of pk and sh.	148	49	49	16
Deviations	- 8	+12	+11	-14
	X^2 equals 18.32 P equals .00039			
Expected numbers, assuming linkage between pk and sh, with 10 % crossing over	134	63	63	3
Deviations	+ 6	- 2	- 3	-1
	X^2 equals .80 P equals .8013 plus			



THE POLKADOT PATTERN

FIGURE 17. The yellow tissue appears light and the green tissue dark in the photograph. Often the green is reduced to circular areas in the yellow, giving the peculiar polkadot pattern. The polkadot character is inherited as a recessive, although in some crosses the pattern "shows through" to a certain extent in the first generation plants, where normal green leaves would be expected.

in this case is 9.67. Deviations as wide would be expected about once in fifty similar trials.

In Table IV are progenies which segregated colored and colorless kernels in the ratio of 27:37, thus indicating that the parent plants were heterozygous for three aleurone color factors. Here again the deviations between the numbers observed and the numbers expected, assuming independent inheritance of *pk* and the aleurone color factors, are wide with X^2 equal to 49.56. By assuming, as previously, a linkage between *pk* and one of the aleurone color factors, with two per cent crossing over, the observed numbers are in fairly close agreement with the expected numbers. X^2 has a value of 5.04. Equally large deviations would be expected in seventeen out of one hundred similar trials.

There is some evidence to show that it is the *C* aleurone color factor that is linked with *pk*. In table V are given data in small numbers on the segregation of *pk* and *sh*. The deviations between the observed and expected numbers for independent inheritance are wide, X^2 having a value of 18.32. By assuming a linkage between *pk* and *sh*, with ten per cent crossing over, the observed numbers are in close agreement with expectation. X^2 has a value of 0.80. In about nine out of ten trials deviations as large would be expected. The numbers are too small to be more than simply an indication of linkage. The data at hand are fairly good evidence that *pk* belongs to the *c-sh-wx* linkage group.

Summary

The chlorophyl pattern, *polkadot leaves*, was first observed in an inbred strain of Boone County White maize. Polkadot leaves are represented factorially by *pk*. The factor *pk* probably belongs to the *c-sh-wx* linkage group.